California Environmental Protection Agency
Air Resources Board

APPENDICES

INITIAL STATEMENT OF REASONS FOR THE PROPOSED AMENDMENTS TO THE ASBESTOS AIRBORNE TOXIC CONTROL MEASURE FOR SURFACING APPLICATIONS

Stationary Source Division
Emissions Assessment Branch

Release Date
June 2, 2000

Appendix A

Copy of the Proposed Revisions
to the
Asbestos Airborne Toxic Control Measure

PROPOSED REGULATION ORDER

ASBESTOS AIRBORNE TOXIC CONTROL MEASURE FOR SURFACING APPLICATIONS

[Note: The proposed amendments to Section 93106 are shown in ~~strike-out~~ to indicated proposed deletions and underline to indicate proposed additions.]

Section 93106. Asbestos Airborne Toxic Control Measure ~~—Asbestos-Containing Serpentine~~ for Surfacing Applications.

(a) Definitions. For the purposes of this section, the following definitions shall apply:

(1) "Aggregate" means a mixture of mineral fragments, sand, gravel, rocks, or similar minerals.

(2) "Alluvial deposit" means any deposit of sediments laid down by running water including but not limited to streams and rivers.

(3) "Approved asbestos bulk test method" means ARB Test Method 435 or an alternative asbestos bulk test method approved in writing by the Executive Officer of the Air Resources Board.

(4) "ARB" means the California Air Resources Board.

~~(3)~~(5) "ARB Test Method 435" means the test method specified in Title 17, California Code of Regulations, section 94147.

~~(4)~~(6) "Asbestos" means asbestiforms of the following hydrated minerals: chrysotile (fibrous serpentine), crocidolite (fibrous riebeckite), amosite (fibrous cummingtonite--grunerite), fibrous tremolite, fibrous actinolite, and fibrous anthophyllite.

(7) "Asbestos-containing material" means any material that has an asbestos content of 0.25 percent or more as determined by an approved asbestos bulk test method

~~(5) "Asbestos-containing serpentine material" means serpentine material that has an asbestos content greater than five percent (5.0%) as determined by ARB Test Method 435.~~

(8) "Asbestos geologic assessment" means a geologic evaluation of a property conducted by a registered geologist to determine the presence of asbestos, asbestos-containing material, or ultramafic rock.

(9) "District" means any air pollution control or air quality management district created or continued in existence pursuant to Part 3 (commencing with section 40000), Division 26, Health and Safety Code.

(10) "Executive Officer" means the Executive Officer of the ARB, the executive officer or air pollution control officer of any district, or designee thereof.

(11) "Non-wearing surface" means any non-road surface that has an incline greater than twenty (20) percent, including, but not limited to, the use of riprap, road cuts, or soil stabilization.

(12) "Owner/operator" or "person" includes, but is not limited to, an individual, trust, firm, joint stock company, business concern, partnership, limited liability company, association, or corporation including, but not limited to, a government corporation. "Owner/operator" or "person" also includes any city, county, district, commission, the state or any department, agency, or political subdivision thereof, any interstate body, and the federal government or any department or agency thereof to the extent permitted by law. "Owner/operator" or "person" also includes a project proponent and any of its contractors and subcontractors.

(13) "Producer" means any person that extracts and processes aggregate material from the ground.

~~(6)~~(14) "Receipt" means any written acknowledgement that a specified amount of serpentine, serpentine material, or ultramafic rock was received, delivered, or purchased. Receipts include, but are not limited to, bills of sale, bills of lading, and notices of transfer.

(15) "Registered geologist" means an individual that is currently licensed with the State of California, Department of Consumer Affairs, Board of Geology and Geophysicists as a geologist.

(16) "Remote location" means any location that is at least one (1.0) mile from the location of a receptor, which includes, but is not limited to, hospitals, schools, day care centers, work sites, businesses, residences, and permanent campgrounds. The distance of one (1.0) mile is to be measured from the outer most limit of the area to be disturbed or road surface, whichever is further.

~~(7)~~(17) "Road surface" means the traveled way of a road and any shoulder which may extend~~s~~ up ten (10) feet from the edge of the traveled way.

~~(8)~~(18) "Sand and gravel operation" means any aggregate-producing facility operating in alluvial deposits.

~~(9)~~(19) "Serpentine" means any form of hydrous magnesium silicate minerals – including, but not limited to, antigorite, lizardite, and chrysotile.

~~(10)~~(20) "Serpentine material" ~~is~~ means any material that contains at least ten percent (10%) serpentine as determined by a registered geologist. The registered geologist must document precisely how the serpentine content of the material in question was determined.

(21) "Serpentinite" means a rock consisting almost entirely of serpentine, although small amounts of other minerals such as magnetite, chromite, talc, brucite, and tremolite-actinolite may also be present.

~~(11)~~(22) "Surfacing" means the act of covering any surface used for pedestrian, vehicular, or non-vehicular travel; or decoration, including, but not limited to, roads, road shoulders, streets, access roads, alleys, lanes, driveways, parking lots, playgrounds, trails, squares, plazas, and fairgrounds.

(23) "Ultramafic rock" means an igneous rock composed chiefly of one or more iron/magnesium-rich, dark-colored minerals such as pyroxene, amphibole, and olivine; includes, but is not limited to serpentinite, dunite, peridotite, and pyroxenite.

~~(b) Requirements for use or sale of asbestos-containing serpentine material.~~

~~(1) No person shall use or apply serpentine material for surfacing in California unless the material has been tested using ARB Test Method 435 and determined to have an asbestos content of five percent (5.0%) or less. A written receipt or other record documenting the asbestos content shall be retained by any person who uses or applies serpentine material, for a period of at least seven years from the date of use or application, and shall be provided to the Air Pollution Control Officer or his designee for review upon request.~~

~~(2) Any person who sells, supplies, or offers for sale serpentine material in California shall provide with each sale or supply a written receipt containing the following statement: "Serpentine material may have an asbestos content greater than five percent (5.0%). It is unlawful to use serpentine material for surfacing unless the material has been tested and found to contain less than or equal to five percent (5.0%) asbestos. All tests for asbestos content must use California Air Resources Board Test Method 435, and a written record documenting the test results must be retained for at least seven years if the material is used for surfacing.~~

~~(3) No person shall sell, supply, or offer for sale serpentine material for surfacing in California unless the serpentine material has been tested using ARB Test Method 435 and determined to have an asbestos content of five percent (5.0%) or less. Any person who sells, supplies, or offers for sale serpentine material that he or she represents, either orally or in writing, to be suitable for surfacing or to have an asbestos content that is five percent (5.0%) or less, shall provide to each purchaser or person receiving the serpentine material a written receipt which specifies the following information: the amount of serpentine material sold or supplied; the dates that the serpentine material was produced, sampled, tested, and supplied or sold; and the asbestos content of the serpentine material as measured by ARB Test Method 435. A copy of the receipt must, at all times, remain with the serpentine material during transit and surfacing.~~

~~(4) Any person who sells, supplies, or offers for sale serpentine material, shall retain for a period of at least seven years from the date of sale or supply, copies of all receipts and copies of any analytical test results from asbestos testing of the serpentine material. All receipts and test results shall be provided to the Air Pollution Control Officer or his designee for review upon request.~~

[Note: The existing language in subsection 93106(b) has been reorganized and amended. Some of the language shown below in new subsections (b), (c), and (d) is new language, and some is language that currently appears in the existing subsection 93106(b)(1) through (b)(4). To improve the readability of the proposed amendments, however, the entire text of the existing subsection 93106(b)(1) through (b)(4) has been struck out, and all of the language in new subsections (b), (c), and (d) is shown in underline format.]

(b) Prohibitions on the Use or Sale of Certain Materials for Surfacing

(1) The Executive Officer may require testing for the asbestos content of any material represented as being suitable or used for surfacing.

(2) No person shall use, apply, sell, supply, or offer for sale or supply any of the following materials for surfacing, unless one of the exemptions listed in subsections (f) or (b)(3) applies:

(A) Serpentine or serpentine material,

(B) Ultramafic rock, or

(C) Any material that has been tested and found to have an asbestos content of 0.25 percent or more.

(3) *Exemption for Ultramafic Rock that Has Been Tested:* Ultramafic rock may be used, applied, offered for sale or supply, sold, or supplied for surfacing, if the rock has been tested using an approved asbestos bulk test method, and has been determined to contain less than 0.25 percent asbestos.

(4) *Nonsurfacing Applications:* All of the materials listed above in (b)(2) may be used, applied, offered for sale or supply, sold, or supplied for nonsurfacing applications. However, the noticing requirements specified in section (c)(3) must be complied with, as well as the recordkeeping and reporting requirements specified in subsection (d)(3).

(c) Noticing Requirements

(1) *Noticing Requirements for Producers of Ultramafic Rock for Surfacing.* A producer is any person that extracts and processes aggregate material from the ground. Any producer who sells, supplies, or offers for sale or supply ultramafic rock that the person represents, either orally or in writing, as being suitable for surfacing, must provide to the recipient of the ultramafic rock a written receipt that displays all of the following information:

(A) The amount of ultramafic rock sold or supplied;

(B) The dates that the ultramafic rock was sampled and tested, or a statement that the material is exempt pursuant to subsection (f)(6);

(C) The asbestos content of the ultramafic rock, if tested; and

(D) The dates that the ultramafic rock was supplied or sold.

(2) *Noticing Requirements for Persons, Other than Producers, Who Sell Ultramafic Rock for Surfacing.* Any person, other than a producer, who sells, supplies, or offers for sale or supply ultramafic rock that the person represents, either orally or in writing, as being suitable for surfacing, must provide to the recipient of the ultramafic rock a written receipt that displays all of the following information:

(A) The amount of ultramafic rock sold or supplied;

(B) The dates that the ultramafic rock was sold or supplied; and

(C) Verification that the asbestos content of the ultramafic rock is less than 0.25 percent.

(3) *Noticing Requirements for Persons Who Sell Material for Nonsurfacing Applications.* Any person who sells, supplies, or offers for sale or supply any of the following materials:

(A) Serpentine or serpentine material,

(B) Ultramafic rock that has not been tested,

(C) Ultramafic rock that has been tested and found to have an asbestos content of 0.25 percent or greater; or

(D) Any material that has been tested and found to have an asbestos content of 0.25 percent or greater,

must provide with each sale or supply a written receipt that displays the following statement:

"WARNING!
This material may contain asbestos.

It is unlawful to use this material for surfacing or any application in which it would remain exposed and subject to possible disturbances.

Extreme care should be taken when handling this material to minimize the generation of dust."

(4) All of the written notices and statements required by this section must be displayed in such a manner that they are readily observable and clearly legible.

(d) Recordkeeping and Reporting Requirements

(1) *Recordkeeping Requirements for Persons who Use or Apply Ultramafic Rock for Surfacing:* Any person who uses or applies ultramafic rock (other than serpentine) for surfacing must retain any written receipt or other record verifying that the material is suitable for surfacing for a minimum of seven years from the date the material is used or applied. In addition, the person must have a copy of any receipt or record at all times during the actual application of the ultramafic rock for surfacing.

(2) *Recordkeeping Requirements for Persons who Transport Utramafic Rock for Surfacing:* Any person who transports ultramafic rock for surfacing must maintain a copy of any receipt or record required by subsection (c) with the ultramafic rock at all times during transport.

(3) *Recordkeeping Requirements for Persons who Sell or Supply Serpentine, Serpentine Material, or Ultramafic Rock:* Any person who sells, supplies, or offers for sale or supply serpentine, serpentine material or ultramafic rock must retain copies of all receipts, and any analytical test results from asbestos testing of the rock, for a minimum of seven years from the date of sale or supply.

(4) *Reporting Requirements:* Any receipts, records, or test results referred to in this section shall be provided to the Executive Officer for review upon request.

(e) Test Methods

(1) ARB Test Method 435 or an alternative asbestos bulk test method approved in writing by the Executive Officer of the Air Resources Board shall be used to determine compliance with this section. For the purposes of determining compliance with this section, references in ARB Test Method 435 to "serpentine aggregate" shall mean "aggregate material."

~~(5)~~(2) If ARB Test Method 435 or an alternative asbestos bulk test method approved in writing by the Executive Officer of the Air Resources Board has been used to perform two or more tests on any one volume of ~~serpentine~~ material, whether by the same or a different person, ~~the arithmetic average of these test results shall be used to determine the asbestos content of the serpentine~~ the test results indicating the greater amount of asbestos shall be used to determine the presence of asbestos in the material.

~~(c)~~(f) Exemptions.

(1) *Sand and Gravel Operations*: The provision of subdivisions (b)(2)(A), (b)(2)(B), (c) and (d) ~~through (b)(5)~~ shall not apply to aggregate extracted from sand and gravel operations.

(2) *Roads located at Surface Mining Operations*: The provisions of subdivision (b)~~(1)~~ shall not apply to roads located at ~~serpentine quarries, asbestos mines,~~ quarries or mines ~~located in serpentine deposits~~ that are in ultramafic rock units ~~or asbestos mines,~~ provided the material was obtained on site from the quarry or mine property.

~~(3) *Maintenance Operations on Existing Roads*: The provisions of subdivision (b)(1) shall not apply to maintenance operations on any existing road surfaces, or to the construction of new roads in serpentine deposits, as long as no additional asbestos-containing serpentine material is applied to the road surface.~~

(3) *Emergency Road Repairs*: The ~~air pollution control officer~~ Executive Officer may issue a temporary exemption from the requirements of subdivision (b)~~(1)~~ to an applicant who demonstrates that a road repair is necessary due to a landslide, flood, or other emergency and that the use of material other than serpentine or ultramafic rock is not feasible for this repair. The ~~air pollution control officer~~ Executive Officer shall specify the time during which such exemption shall be effective, provided that no exemption shall remain in effect longer than ~~six (6) months~~ 90 days.

(4) *Bituminous and Concrete Materials*: The provisions of subdivision (b)~~(1)~~, (c) and (d) shall not apply to serpentine, serpentine material, or ultramafic rock that is an integral part of the production of bituminous concrete, portland cement concrete, or construction of a bituminous surface, or other similar cemented materials.

(5) *Landfill Operations*: The provisions of subdivision (b)~~(1)~~ shall not apply to landfill operations other than the surfacing of public-access roads dedicated to use by vehicular traffic.

(6) *Geologic Assessment:* The Executive Officer may provide an exemption from subdivisions (b)(2)(B) and (c)(3) for aggregate composed of ultramafic rock other than serpentine provided a registered geologist has conducted an asbestos geologic assessment of the property from which the aggregate was obtained and determined that asbestos is not likely to be found in any of the ultramafic rock located on the property. The owner/operator shall provide a written copy of the asbestos geologic assessment to the Executive Officer for his consideration when providing this exemption.

(7) *Non-wearing surfaces*: The Executive Officer may provide an exemption from the provisions of subdivision (b) for the use of aggregate on non-wearing surfaces provided that the owner/operator can demonstrate that:

(A) There are no reasonably alternative aggregate available; and

(B) The surface is not located in an area zoned or identified in a land use plan for civic, residential, or commercial use;

(8) *Remote locations:* The Executive Officer may provide an exemption from the provisions of subdivision (b) for the use of aggregate on unpaved provided that:

(A) The own/operator can demonstrate that:

1. The surface is located in a remote location; and

2. There are no reasonably available alternative aggregate.

(B) In providing this exemption, the Executive Officer shall:

1. Consider the following information: county land use plans, the current use of the surrounding land, and the current and anticipated zoning designations;

2. Provide public notice and solicit comments for a 30-day period before providing this exemption; and

3. Require that any surface exempted pursuant to this subdivision be posted with a permanent sign alerting the public to potential asbestos exposures.

NOTE: Authority cited: Sections 39600, 39601, 39650, 39658, 39659, 39666, and 41511, Health and Safety code. Reference: Sections 39650, 39658, 39659, 39666, and 41511, Health and Safety Code..

Appendix B

Copy of Asbestos Task Force

White Paper (May 15, 1998)

Findings and Recommendations (March 11, 1999)

Naturally-Occurring Asbestos in El Dorado County

What is naturally-occurring asbestos and where is it found?

Asbestos is a term used for several types of naturally occurring fibrous minerals. The most common and abundant type found in El Dorado County is chrysotile, but tremolite asbestos has also been found. Both types of asbestos occur naturally in serpentine rock, but tremolite may also occur in certain other common rocks, especially near faults. Asbestos is not found in all serpentine rock or fault zones. When it does occur, it is typically present in amounts ranging from less than 1% up to about 25% of the rock volume, and in rare instances, even greater amounts. This variability can occur within the same serpentine rock outcropping.

Serpentine rock is typically grayish-green to bluish-black in color, and may have a greasy or shiny appearance. Serpentine rock is abundant in the Sierra foothills, the Klamath Mountains, and the Coast Ranges, where it is commonly exposed near faults. Faults often appear as zones in which the rocks are fractured, distorted, and displaced and may range from a few feet to a mile or more in width. Knowledge of fault locations is important because asbestos occurs most commonly where serpentine and certain other common rocks are intersected by faults. However, not all fault zones contain asbestos. On regional geologic maps, serpentine rock is often grouped by geologists with other related rocks into areas called "ultramafic rocks." Tremolite asbestos occurs most often at the margins of areas of ultramafic rocks and where serpentine and other common rocks are intersected by faults.

The attached map of western El Dorado County, prepared by the Department of Conservation, Division of Mines and Geology, shows locations of ultramafic rock and fault zones. These are the areas where varying amounts of serpentine rock may occur. This map shows the general locations of the more significant ultramafic rock areas and faults where serpentine rock, chrysotile asbestos, and tremolite asbestos may occur, not the presence or absence of asbestos at specific sites.

How does asbestos from serpentine rocks become airborne?

One of the primary sources of airborne asbestos is from the dust generated from unpaved roads. Cars driving over unpaved roads or driveways made from crushed serpentine rock may further break up the rock and create dust that may contain asbestos fibers. Asbestos is also released when serpentine rock is broken or crushed during activities such as construction, grading, or quarrying operations. Natural weathering and erosion of serpentine rock releases asbestos fibers slowly. For example, rain may wash asbestos fibers from serpentine rock and the fibers may then be blown by the wind when the ground becomes dry. Once asbestos fibers become airborne they may stay in the air for long periods of time. Asbestos-containing dust can be blown into homes and businesses or be tracked indoors on shoes or clothes.

What are the levels of exposure to asbestos in El Dorado County?

Currently, there are only limited data on the levels of asbestos in the air that can be used to determine the exposures of people living and working in El Dorado County. Much of the County likely has little or no airborne asbestos; however, other areas near disturbed serpentine rock such as construction sites, quarry operations, or unpaved roads and driveways surfaced with asbestos-containing serpentine rock could have elevated levels. As mentioned, activities which disturb or break serpentine rock, such as driving on unpaved roads surfaced with this rock, can cause asbestos to be released. The Air Resources Board (ARB), with the participation of the El Dorado County Air Pollution Control District, has initiated an air monitoring program to determine airborne asbestos levels in the County. During this monitoring program, asbestos levels will be measured at various locations throughout the County to better evaluate public exposures. The monitoring program will continue in the summer months to assure collection of measurements that are representative of a variety of conditions. In addition, others are independently conducting air monitoring for asbestos. All of this information will be gathered and reviewed to help us to better characterize public exposures and prioritize efforts to reduce significant exposures.

What are the health effects from exposure to asbestos?

The principal health effects that have been linked to asbestos exposure are lung cancer, asbestosis, and mesothelioma. Lung cancer is a relatively common form of cancer that has also been linked to smoking and a variety of occupational exposures. Asbestosis is a chronic, degenerative lung disease that has been primarily observed among workers in asbestos-related industries. Mesothelioma is a rare cancer of the thin membranes lining the lungs, chest, and abdominal cavity.

Some asbestos fibers can penetrate body tissues and remain in the lungs and the tissue lining the lungs and abdominal cavity. The fibers that remain in the body are thought to be responsible for asbestos-related diseases. These diseases may take decades to occur. There has been some scientific disagreement on whether certain types of asbestos are less hazardous than others. State and federal health professionals consider all types of asbestos to be hazardous.

Any exposure to asbestos involves some risk. The longer a person is exposed to asbestos and the greater the intensity of the exposure, the greater the chances for a health problem. Since the risk is related to the total exposure, exposure to low levels of asbestos for short periods of time poses minimal risk. Most of the information on health effects comes from studies of people who were regularly exposed to high levels of asbestos in the workplace. Occupational exposures are higher and much more likely to cause disease than non-occupational exposures. However, recent information indicates that asbestos-related disease can be caused by non-occupational exposures such as those resulting from the disturbance and release of asbestos into the air. Thus, the most important way to reduce asbestos risk is to reduce exposure to airborne fibers.

What can be done to reduce asbestos from being released into the air?

Unpaved roads, construction projects, quarries, and unpaved driveways are the most likely sources of airborne asbestos in and near serpentine rock areas. There are some widely-accepted control actions that, when properly applied, will reduce the release of asbestos dust. These actions include:

- wetting of surfaces during excavation and building;
- paving or sealing roads and driveways;
- rinsing construction vehicles;
- covering loads of excavated materials;
- covering exposed crushed serpentine soils with clean soils; and
- planting vegetation to reclaim disturbed serpentine rock areas.

These measures will reduce asbestos from being released by keeping the dust bound to the soil with moisture or encased by either an artificial or natural covering.

What precautions can individuals take to reduce their potential asbestos exposures?

The first action that an individual can take is to identify the location of serpentine rock on or near the property. If you are unsure whether the rock on your property is serpentine, you may consider contacting a registered geologist. Once identified, you can generally reduce your exposure by minimizing dust generation in and around your home. Some actions you may want to consider include:

- pave over unpaved walkways or roadways which contain serpentine rock and cover all finely crushed serpentine rock within residential yards with clean soil;
- pre-wet serpentine rock garden areas prior to working the soil;
- use a damp rag when dusting (as opposed to a feather duster); and
- wash vehicles that have been in direct contact with dust from crushed serpentine rock.

What requirements are in place to reduce naturally-occurring asbestos emissions?

Historically, fugitive dust and nuisance regulations have been in place to control dust from construction and quarry activities. In April 1998, the El Dorado County Board of Supervisors adopted an interim ordinance to ensure that construction activities in the County are done in a manner which minimizes the release of asbestos fibers into the air. The ordinance requires builders in serpentine areas to:

- pre-wet work areas;
- limit vehicle access and speed;
- cover areas exposed to vehicle travel with non-asbestos material;
- maintain high moisture conditions or apply a "binder" to seal fibers of disturbed surfaces or stockpiles; and
- provide employee notification of potential exposures and risk.

The El Dorado County Board of Supervisors has directed the Director of Environmental Management to ensure compliance with this ordinance throughout the County.

In addition, if asbestos is suspected in a work area, the federal and California Occupational Safety and Health Administrations have regulations to protect workers. Basically, the regulations require air monitoring to determine if asbestos concentrations exceed certain levels. If the levels are exceeded, steps to eliminate or mitigate the asbestos hazards are required. These rules do not apply to workers in mines or mills, which are regulated under the federal Mine Safety and Health Administration.

Also, the El Dorado County Air Pollution Control District implemented an existing ARB control measure, which became effective in 1991, that prohibits the use of serpentine material for surfacing applications if it contains greater than 5% asbestos. This regulation also includes requirements that quarry operators test for the asbestos content of serpentine rock sold for surfacing purposes.

What other actions are being taken?

A Task Force of public officials and state and local agencies has been set up to address the issue of naturally-occurring asbestos in El Dorado County. This Task Force is currently identifying issues related to asbestos exposure, facilitating testing to determine airborne levels, and developing methods to assess overall potential risk to residents of the County. The information generated will better assist State and local agencies in taking appropriate steps to safeguard public health statewide. Further measures for reducing exposure to asbestos which can be taken by individuals and public agencies will also be examined.

Who can I call for further information?

This document is a brief summary based on generally available information and existing knowledge of the issues related to naturally-occurring asbestos in El Dorado County. As more information becomes available, additional releases may be prepared.

Senator Tim Leslie
District Office
(916) 969-8232

Assemblyman Rico Oller
District Office
(916) 774-4430

Ron Duncan
Director of Environmental Management
El Dorado County
(530) 621-5303

Where can I get more information?

This paper, as well as additional links to asbestos related sites, can be accessed electronically at: www.arb.ca.gov/toxics/asbestos.htm

Additional information will soon be available on the California Environmental Protection Agency Hotline at: 1-800-CLEANUP (253-2687)

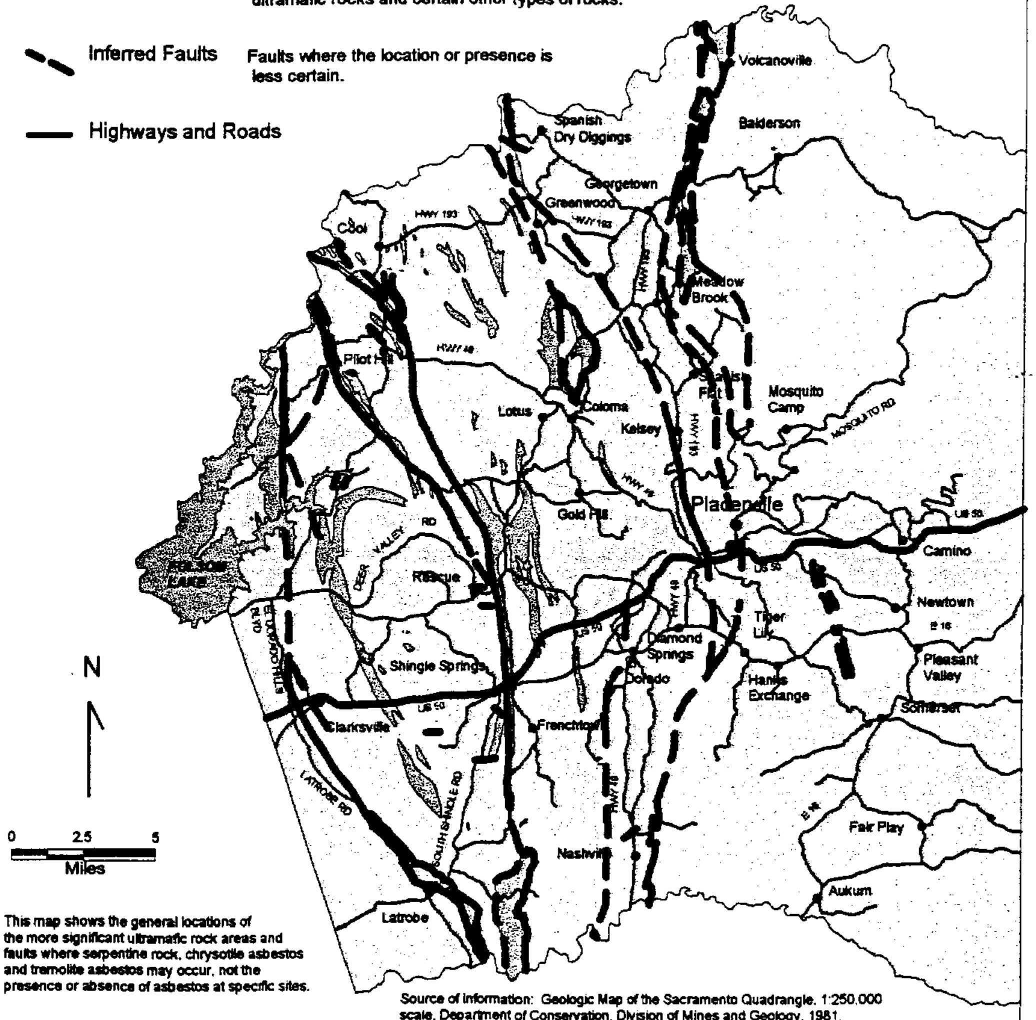
This information was developed with participation by:

Senator Tim Leslie's Office
El Dorado County Board of Supervisors
El Dorado County Air Pollution Control District
California Department of Conservation
California Environmental Protection Agency
  Air Resources Board
  Office of Environmental Health Hazard Assessment
  Department of Toxic Substances Control

Assemblyman Rico Oller's Office
United States Geological Survey
California Department of Health Services
University of California at Davis, Geology Dept.
Aeolus Environmental Services

LOCATIONS OF ULTRAMAFIC ROCKS AND FAULTS IN EL DORADO COUNTY WHERE SERPENTINE ROCK AND ASBESTOS MAY OCCUR

▨	Ultramafic Rocks	Areas containing serpentine rock and related rock types; chrysotile and tremolite asbestos may be present, particularly near faults.
□	Non-Ultramafic Rocks	May contain areas of ultramafic rocks too small to show on this map or not included on the source map.
╲	Known Faults	Zones of rock fracturing and displacement, from a few feet to a mile or more wide in some locations. Tremolite asbestos is most likely to occur where faults intersect ultramafic rocks and certain other types of rocks.
╲ ╲	Inferred Faults	Faults where the location or presence is less certain.
━	Highways and Roads	



This map shows the general locations of the more significant ultramafic rock areas and faults where serpentine rock, chrysotile asbestos and tremolite asbestos may occur, not the presence or absence of asbestos at specific sites.

Source of information: Geologic Map of the Sacramento Quadrangle, 1:250,000 scale, Department of Conservation, Division of Mines and Geology, 1981.

The Department of Conservation, Division of Mines and Geology, May 12, 1998.

Asbestos Task Force

Findings and Recommendations on Naturally-Occurring Asbestos To El Dorado County

March 11, 1999

ASBESTOS TASK FORCE PARTICIPANTS

Senator Tim Leslie's Office
Robert Dugan
Michelle Rochon

El Dorado County Board of Supervisor
Supervisor Sam Bradley
Supervisor Penny Humphreys

El Dorado County Air Pollution Control District
Ron Duncan

California Department of Conservation
Ron Churchill

California Environmental Protection Agency
Ken Selover

Air Resources Board
Don Ames
Jerry Martin
George Lew
Todd Wong
Carolyn Suer
Victor Douglas

Office of Environmental Health Hazard Assessment
George Alexeeff, Ph.D.
Melanie Marty, Ph.D.
Michael Lipsett, Ph.D.

Department of Toxic Substances Control
Fran Anderson
Dan Ziarkowski

Assemblyman Rico Oller's Office
Dana Jorgensen

United States Geological Survey
Roger Ashley
Victor Mossotti

California Department of Health Services
Rick Kreutzer, Ph.D.

University of California at Davis Geology Department
Professor Howard Day

Findings and Recommendations of the Task Force on Naturally-Occurring Asbestos

Beginning in late March 1998, the Sacramento Bee ran a series of articles raising issues related to the risks from naturally-occurring asbestos in El Dorado County (the County). To address those issues, a Task Force (a list of participants is included at the end of this paper) was formed in response to a request from Senator Tim Leslie, Assemblyman Rico Oller, and El Dorado County officials to the California Environmental Protection Agency (Cal/EPA). Cal/EPA responded to this request by offering the technical assistance of its staff and enlisting the help of other State and federal agencies. The Task Force is a volunteer group consisting of public officials and representatives of federal, State, and local agencies formed to provide advice to local officials in El Dorado County regarding asbestos. The Task Force is not an official State-appointed entity that can make policy and enforce regulations.

The Task Force reviewed the issues raised, distributed a White Paper, which contained pertinent information for County residents, held a public forum to respond to the public's questions, and helped to facilitate testing to determine ambient airborne levels of asbestos and assess the potential risks associated with those levels. This document contains a chronology of the major actions taken by the Task Force, an overview of the air monitoring data gathered in El Dorado County, and the findings and recommendations of the Task Force with regard to the information gathered through this process for consideration by El Dorado County officials.

Chronology of Task Force Actions

A chronology of actions taken by the Task Force is shown below:

April 3, 1998	Cal/EPA offer of assistance to El Dorado County
April 14, 1998	Organizational meeting of the Task Force
April 21, 1998	Air Resources Board begins air monitoring
Ongoing since April 1998	Ambient monitoring in El Dorado County
April 24, 1998	Task Force meeting
May 8, 1998	Task Force meeting
May 15, 1998	Publication of the White Paper
May 22, 1998	Task Force meeting
June 1998	Publication of six Fact Sheets on asbestos
June 5, 1998	Task Force meeting
June 8, 1998	Public forum at Oak Ridge High School
June 10, 1998	Press and Task Force tour of monitoring sites
June 19, 1998	Task Force meeting
October 16, 1998	Task Force meeting
February 11, 1999	Task Force meeting
March 11, 1999	Release of final report on findings and recommendations

In addition to these actions, a technical subcommittee on monitoring held several meetings and Task Force members have met with individuals upon request.

Overview of Air Monitoring Efforts

The Air Resources Board (ARB) conducted ambient air monitoring at 30 different locations in the County. The locations were selected based, in part, on suggestions by the public. Most of the ARB monitoring was generally intended to provide information on the levels of asbestos that most residents of the County would be exposed to over an extended period of time. Other locations were chosen to provide data on the asbestos concentrations in the vicinity of a particular site of interest, such as a school or residential neighborhood. A listing of the locations is available from the ARB website (www.arb.ca.gov/toxics/asbestos.htm).

On November 3, 1998, the ARB staff released the results of 226 samples that had been collected and analyzed (Phase 1 Monitoring). The focus of this monitoring effort was to determine if there is a widespread and constant pattern of elevated asbestos exposures in the County. Of the 226 air samples analyzed, asbestos was detected in 40 samples. About half of these samples were at the minimum detection level, where only one asbestos fiber was detected. The presence of one asbestos fiber on a filter may be caused by contamination and may not represent a true positive result. Samples with only one fiber detected on the filters are not as strong of an indicator as samples with multiple fibers due to potential contamination during the handling and transportation of the filters. Further testing of those sites with the potential for elevated asbestos concentrations will be considered for future monitoring.

On January 15, 1999, the ARB staff released monitoring results of 139 samples collected at 8 monitoring locations near a serpentine quarry in El Dorado County (Phase 2 Monitoring). Asbestos was detected on 107 of these samples, with many having more than one asbestos fiber detected on the filter. The detailed results of the monitoring data for Phase 1 and Phase 2 monitoring are available on the ARB website address shown above. The estimated risks based on the results of the Phase I and 2 monitoring are discussed in the findings below.

Findings and Recommendations of the Task Force

1. *The Task Force finds that the ARB monitoring data indicate: (1) there is not widespread exposure to elevated levels of asbestos in the ambient air of El Dorado County; (2) the general population does not appear to be exposed to significant risks from naturally-occurring asbestos; and (3) potential exposure to elevated asbestos concentrations and corresponding increased health risks may occur near certain sources such as unpaved roads and quarries.*

   From the Phase 1 monitoring program, 40 of 226 samples had positive results. About half of the 40 positive results had an associated lung cancer or mesothelioma risk of between 10 to 50 chances per million assuming that a person would be continuously breathing those levels for 24 hours a day for 70 years. The other half of the positive results were at the minimum detection level of one asbestos fiber per sample. The potential risk for lung cancer or mesothelioma associated with a positive sampling result at the minimum detection level, is between 5 to 10 chances per million people exposed. Based on these monitoring results, it appears unlikely that the general population of

El Dorado County is exposed to widespread, elevated asbestos levels from undisturbed, naturally-occurring asbestos.

To put these risk numbers into perspective, in California approximately 200,000 cases of cancer are expected in a population of one million during a 70 year lifetime. In this report, a probability or risk estimate of one in one million means that, on average, one additional case of cancer due to exposure to asbestos might be expected in that population of one million. All risk estimates presented here are based on health-protective assumptions, including that a person is continuously exposed for 24 hours a day for 70 years. These risk estimates are considered to be upper limits and the number of cancer cases associated with specific levels would not be expected to be exceeded.

The Phase 2 monitoring program detected some higher asbestos concentrations near a serpentine quarry. From the sampling results, it was estimated that the potential risk, when averaged at each site, ranged from about 20 to 300 chances per million people exposed. These estimated risk numbers are based on very limited air monitoring data, and should not be used to characterize the potential risk near the quarry until additional information is gathered.

Recommendation: The Task Force recommends that focused sampling be conducted near potential sources such as quarries, construction sites, and unpaved roads to further define a likely range of public exposures and health risks. The Task Force further endorses the ARB effort to develop a risk management guidance document for use by local air districts to provide additional information on ways to control emissions for construction activities, quarry operations, and unpaved roads.

2. *The Task Force acknowledges that there is no agreed-upon "safe" level of asbestos exposures.*

Asbestos is a known human carcinogen and exposure to any cancer-causing agent involves some level of risk. There is not sufficient scientific information to support the identification of an exposure level at which there would be zero risk of cancer. Therefore, the Task Force cannot determine a "safe" level for asbestos exposure, but offers risk estimates as a tool to help guide risk management decisions which are protective of public health. The Task Force cautions the reader to use all the risk numbers presented in this document as estimates only and not as absolute values. Absolute risks from environmental exposures to asbestos are not firmly established; however, risk estimates are a useful tool when comparing one environmental risk with another.

The estimated risk numbers presented in this document are based on long term exposures to provide maximum health protection. The risk from short-term exposures to elevated concentrations of asbestos, such as those which may occur near excavation or construction activities, is difficult to accurately estimate due to the lack of basic scientific understanding. After years of scientific study, the risks of short-term exposures remain unclear. Consequently, State health officials take the most health-protective approach when estimating risk and assume a person would be exposed for 24 hours a day over a period of 70 years. Calculations based on these assumptions overestimate the true risk of a short-term exposure that may last for only a few weeks or months.

Recommendation: The Task Force recommends that the health-protective approach recommended by the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) continue to be used to calculate risk estimates from long term exposures in order to assure the protection of potentially sensitive groups, particularly children, living in El Dorado County.

3. *The Task Force finds that the risk assessment methods recommended by the OEHHA adequately account for the potentially higher potency of tremolite and other amphibole forms of asbestos.*

The Task Force acknowledges the concern of residents in El Dorado County about potential exposures to both chrysotile and tremolite asbestos. Tremolite is a member of the amphibole class of asbestos, which has a different crystalline structure and chemical composition than the more common chrysotile. For purposes of health risk assessment, the ARB, on the advice of its Scientific Review Panel, the Department of Health Services, and the OEHHA, has considered all forms of asbestos to be equally hazardous. In practice, this means taking a health-protective approach consistent with that adopted by federal regulatory agencies, in which exposure to chrysotile is considered to carry the same degree of risk as exposure to amphibole fibers, including tremolite. In fact, the unit risk value developed by OEHHA, which is used to estimate the risk from asbestos exposures, was based largely on epidemiological studies of workers exposed to amphibole fibers. Therefore, the risk estimates presented for exposures to asbestos in El Dorado County, which is typically chrysotile, are based on a unit risk value which treats the risk from chrysotile fibers the same as that of amphibole fibers (tremolite).

Recommendation: The Task Force recommends the continued use of the OEHHA's current health-protective unit risk value for all asbestos forms.

4. *The Task Force finds that improved modeling approaches would be useful to estimate exposures from various activities which may emit asbestos and that ambient monitoring offers the best information for estimating ranges of exposures at this time.*

Current modeling approaches to estimate asbestos emissions and exposures are based on models used to estimate dust (particulate matter) emissions. These models use the assumption that the asbestos content of the rock or aggregate mixture is in the same proportion as the asbestos content in the air sample. While these models are sometimes used, they have a high degree of uncertainty. The Task Force discussed the use of improved models to estimate the public's exposure to asbestos. The Task Force believes that such an effort may someday be useful for estimating asbestos concentrations from various exposure routes. However, long-term research into developing these types of exposure models was well beyond the scope of this volunteer Task Force.

Recommendation: The Task Force recommends that the appropriate State agencies and the United States Environmental Protection Agency (U.S. EPA) be encouraged to develop improved asbestos exposure models for all possible exposure routes through established research programs. Until such validated models become available, the Task Force recommends that existing emissions estimation techniques and ambient monitoring results be used to estimate exposures.

5. *The Task Force finds that public education is very important to ensure that prudent health protective precautions can be taken by property owners.*

The Task Force commends the efforts of the California Resources Agency's Department of Conservation (DOC) to provide a map of the areas in El Dorado County where asbestos-containing rock and faults may be found. Combined with the information listed below, such data can help residents of the County evaluate actions to minimize the potential for asbestos exposure. There are also reference documents available at the public library on asbestos and many Internet sites with relevant information, including those maintained by the U. S. EPA.

The Task Force has made several informational items available to the public regarding asbestos. These items include:

- a White Paper entitled "Naturally-Occurring Asbestos in El Dorado County"
- a series of Fact Sheets
  - Naturally-Occurring Asbestos: General Information
  - Health Information on Asbestos
  - School Advisory for Naturally-Occurring Asbestos
  - Ways to Control Naturally-Occurring Asbestos Dust
  - Naturally-Occurring Asbestos Around Your Home
  - Monitoring for Asbestos
- a Health Provider Education Fact Sheet
- an Internet site: www.arb.ca.gov/toxics/asbestos.htm
- a Hot Line: 1-800-CLEANUP (253-2687).

In addition, several other informational documents are available from the ARB's Public Information Office to residents of El Dorado County to assist them in asbestos-related decisions regarding their homes, property, and jobs. These documents include:

- Disclosures in Real Property Transactions by the California Business, Transportation and Housing Agency, Department of Real Estate

- CAL-OSHA requirements, California Code of Regulations, Title 8, Subchapter 4, Article 4, Section 1529.

It is important for prospective home or property buyers to be aware of naturally-occurring asbestos. The Task Force encourages the real estate community to disseminate appropriate information.

Recommendation: The Task Force recommends that public education materials continue to be made available. A display of serpentine rock and various asbestos forms, specifically chrysotile and tremolite, is suggested for public buildings where residents of the County can view the material. The County may also consider a visual inspection around all schools and public facilities to determine if possible sources of asbestos, such as serpentine-covered unpaved roads or parking lots, are present. The Task Force also supports the efforts of the DOC to provide maps of potential areas of naturally-occurring asbestos for other areas of the State, pending the identification of adequate funding resources for this effort.

6. *The Task Force finds that construction activities in areas of serpentine or ultramafic rocks are a potential source of short-term, elevated asbestos exposures.*

To address construction activities, the El Dorado County Board of Supervisors adopted a temporary construction ordinance on April 20, 1998, which requires specific actions prior to and during construction activities in specified serpentine rock soils. The ordinance was adopted as an emergency ordinance and has been extended until October 1999. Briefly, this ordinance may require a builder in serpentine areas to develop a dust mitigation plan and in all cases to:

- pre-wet work areas and follow with a fine spray to eliminate visible dust;
- limit vehicle access and speed;
- cover areas exposed to vehicle travel with non-asbestos materials;
- maintain a high moisture condition of disturbed surfaces or apply chemical binder;
- cover or wet material transfers or stockpiles;
- provide employee notification of potential risk; and
- consider worker safety precautions and exposure monitoring.

In addition, the ARB has formed a workgroup with representatives of the California Air Pollution Control Officers Association to develop a risk management document for use by local air districts which may have naturally-occurring asbestos in their jurisdictions. This risk management document will also address construction activities in asbestos outcroppings and is planned for release in 1999.

Recommendation: The Task Force recommends that the El Dorado County Board of Supervisors consider a permanent construction ordinance, including a dust mitigation plan in areas where there is a likelihood of naturally-occurring asbestos and the use of a registered geologist to visually determine if ultramafic rock and asbestos are present or absent. The current ordinance could remain in place until such time that the ARB provides a guidance document that addresses construction activities in areas of naturally-occurring asbestos.

7. *The Task Force finds that unpaved roads or driveways that contain serpentine rock may result in asbestos emissions in concentrations that present a significant potential risk to the public.*

In 1990, the ARB adopted an airborne toxic control measure (ATCM) to limit the asbestos content of serpentine rock to less than 5% when used for surfacing applications, including unpaved roads and driveways. At the time the ATCM was adopted, limited testing of the asbestos content of some unpaved roads and air monitoring near these roads was conducted. The results of those tests showed the content of some serpentine rock to be up to 20% asbestos, with substantial short-term exposures and estimated lifetime risks of potential cancer cases near unpaved roads ranging from about 1,000 to 65,000 per million people exposed. (This range assumes that a person would be continuously breathing those levels for 24 hours a day for 70 years.) Some unpaved roads are in remote locations and do not present a health risk because there are no people regularly exposed. However, if unpaved roads with serpentine rock have people residing near by, the resulting risk from possible asbestos emissions may be significant.

Homeowners also want to know the exposures and risk from unpaved driveways. Due to insufficient information, the Task Force did not estimate the potential risk from unpaved driveways; however, health officials indicate that any exposure to asbestos involves some risk. Asbestos in driveway materials can become airborne when disturbed and remain in the air for long periods of time, contributing to higher exposures. Other situations like playing on the unpaved driveways or being downwind of a heavily traveled unpaved road, may also result in higher exposures. Public education materials discussed previously can help homeowners determine if they have a potential problem and make decisions regarding the need to resurface with non-asbestos materials or pave their driveways.

Recommendation: To minimize future exposures to asbestos from unpaved roads, driveways, and other surfaces the El Dorado County Air Pollution Control District may wish to consider lowering the limit on the asbestos content of serpentine rock for use in surfacing applications from 5% to minimize future exposures to asbestos from unpaved roads, quarries, and other surfaces. There are currently two local air districts in the State, covering four counties, that have adopted lower limits of 1%. Any reduction in asbestos emissions will likewise result in a reduction of risk. The County is also encouraged to give priority to the identification and testing of heavily-traveled unpaved County and private roads that contain serpentine rock.

8. *The Task Force recognizes that quarries are a potential source of airborne asbestos emissions due to the nature of their operations. Quarries should be carefully inspected to ensure that they are in full compliance with all fugitive dust control regulations and any additional regulatory requirements.*

Accounts from several County residents allude to large dust clouds near some operating quarries and questions have been raised whether the fugitive dust regulations are being strictly enforced by the County. Frequent, unannounced inspections by the El Dorado County Air Pollution Control District are encouraged until there is high public confidence of ongoing compliance with dust regulations.

Additional regulatory requirements apply to quarries in California that emit asbestos when serpentine rock is excavated. State law (Health and Safety Code (H&S) sections 44340 et. seq) requires facilities to prepare and submit an inventory plan for specified toxic substances, including asbestos, under the Air Toxics "Hot Spots" Program. This law further directs the local air district to determine if a health risk assessment is required of the facility based on the inventory. If the results of the risk assessment show the potential for significant risk, the local air district must require the facility to notify the public of the potential risks and, in some cases, to prepare an audit and plan to reduce exposures and risks.

The public has also raised concerns about inactive and abandoned mines and quarries. As development encroaches on previously undeveloped areas near potential sources of asbestos, it becomes critical to consider the public health impacts. Proper land use planning decisions are necessary to ensure that inactive or abandoned quarries do not become a public health risk if operations should be reactivated or if abandoned serpentine material is disturbed. Concerns from these sites include storm water run-off, as well, as the potential for air emissions.

Recommendation: If applicable, the El Dorado County Air Pollution Control District should require quarries to report their asbestos emissions under the inventory requirements of the Air Toxics "Hot Spots" Program. These quarries should then be held to any further requirements of the law if the inventory indicates additional actions are needed. In addition, the District may wish to further evaluate the potential for asbestos emissions from quarries to determine if additional actions may be necessary. Some suggested requirements include:

- the evaluation of additional applied dust suppression techniques;
- rinsing of vehicles as they leave the property;
- covering and/or wetting load; and
- routine fence line or downwind residential monitoring for asbestos exposures.

What are the future plans of the Task Force?

The Task Force was formed to respond to the immediate issues and questions raised concerning naturally-occurring asbestos. The Task Force is not a policy making body, but served exclusively to gather information to assist El Dorado County in responding to the issues raised. As those immediate issues and concerns have been addressed, there is no longer a need for the Task Force to continue. However, members of the Task Force, such as the State's ARB, Office of Environmental Health Hazard Assessment, Department of Health Services, Department of Toxic Substances Control, and Department of Conservation will continue to address any asbestos-related questions that may arise. The ARB, in conjunction with California Air Pollution Control Officers Association, is in the process of developing risk management guidance for use by local air districts in addressing the risks from naturally-occurring asbestos. The ARB also plans to continue monitoring next summer in El Dorado County and in other locations in the State. The Task Force supports the ARB in its continuing efforts to better characterize public exposures and risks from asbestos and to provide guidance to local authorities on the various ways available to minimize public exposures.

Where do I get more information?

Ron Duncan Director of Environmental Management El Dorado County (530) 621-5303	Jerry Martin Public Information Officer Air Resources Board (916) 322-2990

This paper, as well as additional links to asbestos related sites, can be accessed electronically at:
www.arb.ca.gov/toxics/asbestos.htm

This information was developed with participation by:

Senator Tim Leslie's Office
El Dorado County Board of Supervisors
El Dorado County Air Pollution Control District
California Department of Conservation
California Environmental Protection Agency
  Air Resources Board
  Office of Environmental Health Hazard Assessment
  Department of Toxic Substances Control

Assemblyman Rico Oller's Office
United States Geological Survey
California Department of Health Services
University of California at Davis, Geology Dept.

Appendix C

Description of Sampling and Monitoring Techniques and Procedures

Airborne Asbestos Analysis
By
Transmission Electron Microscopy

Code of Federal Regulations (CFR) Title 40, Part 763 Appendix A
Asbestos Hazardous Emissions Reduction Act (AHERA)

an accredited inspector under paragraphs (a) (3), (4), (5) of this section, or an architect, project engineer or accredited inspector under paragraph (a)(7) of this section, the local education agency shall have 180 days following the date of identification of ACBM to comply with this subpart E.

APPENDIX A TO SUBPART E—INTERIM TRANSMISSION ELECTRON MICROSCOPY ANALYTICAL METHODS—MANDATORY AND NONMANDATORY—AND MANDATORY SECTION TO DETERMINE COMPLETION OF RESPONSE ACTIONS

I. Introduction

The following appendix contains three units. The first unit is the mandatory transmission electron microscopy (TEM) method which all laboratories must follow; it is the minimum requirement for analysis of air samples for asbestos by TEM. The mandatory method contains the essential elements of the TEM method. The second unit contains the complete non-mandatory method. The non-mandatory method supplements the mandatory method by including additional steps to improve the analysis. EPA recommends that the non-mandatory method be employed for analyzing air filters; however, the laboratory may choose to employ the mandatory method. The non-mandatory method contains the same minimum requirements as are outlined in the mandatory method. Hence, laboratories may choose either of the two methods for analyzing air samples by TEM.

The final unit of this Appendix A to subpart E defines the steps which must be taken to determine completion of response actions. This unit is mandatory.

II. Mandatory Transmission Electron Microscopy Method

A. Definitions of Terms

1. *Analytical sensitivity*—Airborne asbestos concentration represented by each fiber counted under the electron microscope. It is determined by the air volume collected and the proportion of the filter examined. This method requires that the analytical sensitivity be no greater than 0.005 structures/cm^3.

2. *Asbestiform*—A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.

3. *Aspect ratio*—A ratio of the length to the width of a particle. Minimum aspect ratio as defined by this method is equal to or greater than 5:1.

4. *Bundle*—A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

5. *Clean area*—A controlled environment which is maintained and monitored to assure a low probability of asbestos contamination to materials in that space. Clean areas used in this method have HEPA filtered air under positive pressure and are capable of sustained operation with an open laboratory blank which on subsequent analysis has an average of less than 18 structures/mm^2 in an area of 0.057 mm^2 (nominally 10 200-mesh grid openings) and a maximum of 53 structures/mm^2 for any single preparation for that same area.

6. *Cluster*—A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

7. *ED*—Electron diffraction.

8. *EDXA*—Energy dispersive X-ray analysis.

9. *Fiber*—A structure greater than or equal to 0.5 µm in length with an aspect ratio (length to width) of 5:1 or greater and having substantially parallel sides.

10. *Grid*—An open structure for mounting on the sample to aid in its examination in the TEM. The term is used here to denote a 200-mesh copper lattice approximately 3 mm in diameter.

11. *Intersection*—Nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater.

12. *Laboratory sample coordinator*—That person responsible for the conduct of sample handling and the certification of the testing procedures.

13. *Filter background level*—The concentration of structures per square millimeter of filter that is considered indistinguishable from the concentration measured on a blank (filters through which no air has been drawn). For this method the filter background level is defined as 70 structures/mm^2.

14. *Matrix*—Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

15. *NSD*—No structure detected.

16. *Operator*—A person responsible for the TEM instrumental analysis of the sample.

17. *PCM*—Phase contrast microscopy.

18. *SAED*—Selected area electron diffraction.

19. *SEM*—Scanning electron microscope.

20. *STEM*—Scanning transmission electron microscope.

21. *Structure*—a microscopic bundle, cluster, fiber, or matrix which may contain asbestos.

22. *S/cm^3*—Structures per cubic centimeter.

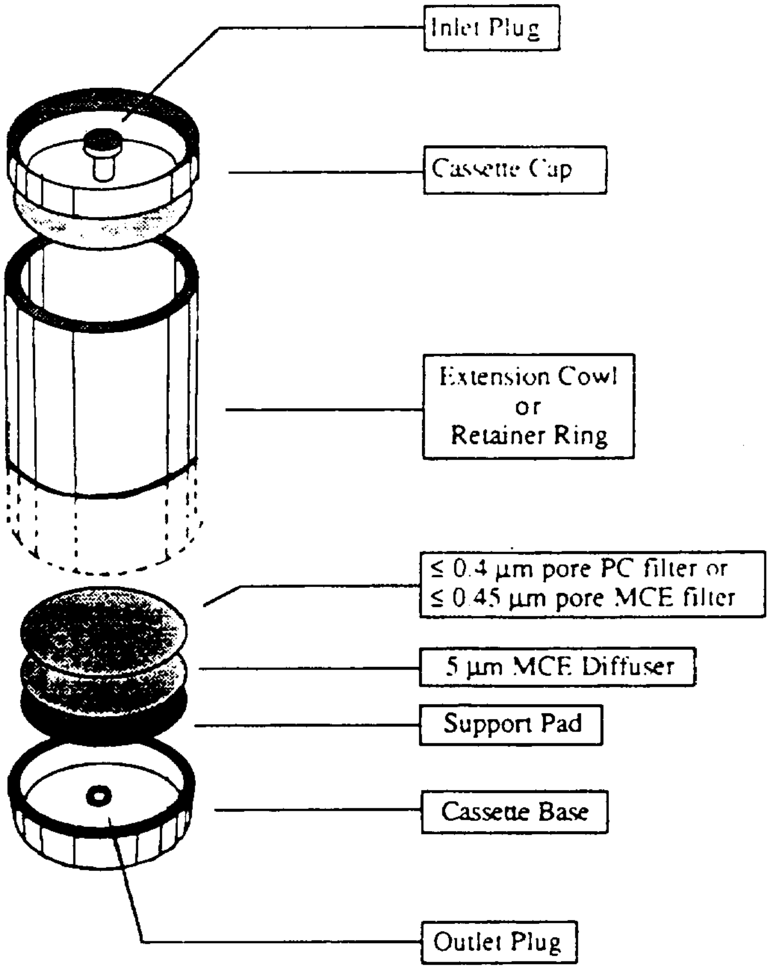
23. *S/mm^2*—Structures per square millimeter.

24. *TEM*—Transmission electron microscope.

B. Sampling

1. The sampling agency must have written quality control procedures and documents which verify compliance.
2. Sampling operations must be performed by qualified individuals completely independent of the abatement contractor to avoid possible conflict of interest (References 1, 2, 3, and 5 of Unit II.J.).
3. Sampling for airborne asbestos following an abatement action must use commercially available cassettes.
4. Prescreen the loaded cassette collection filters to assure that they do not contain concentrations of asbestos which may interfere with the analysis of the sample. A filter blank average of less than 18 s/mm^2 in an area of 0.057 mm^2 (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm^2 for that same area is acceptable for this method.
5. Use sample collection filters which are either polycarbonate having a pore size less than or equal to 0.4 µm or mixed cellulose ester having a pore size less than or equal to 0.45 µm.
6. Place these filters in series with a 5.0 µm backup filter (to serve as a diffuser) and a support pad. See the following Figure 1:

FIGURE I--SAMPLING CASSETTE CONFIGURATION



7. Reloading of used cassettes is not permitted.

8. Orient the cassette downward at approximately 45 degrees from the horizontal.

9. Maintain a log of all pertinent sampling information.

10. Calibrate sampling pumps and their flow indicators over the range of their intended use with a recognized standard. Assemble the sampling system with a representative filter (not the filter which will be used in sampling) before and after the sampling operation.

11. Record all calibration information.

12. Ensure that the mechanical vibrations from the pump will be minimized to prevent transferral of vibration to the cassette.

13. Ensure that a continuous smooth flow of negative pressure is delivered by the pump by damping out any pump action fluctuations if necessary.

14. The final plastic barrier around the abatement area remains in place for the sampling period.

15. After the area has passed a thorough visual inspection, use aggressive sampling conditions to dislodge any remaining dust. (See suggested protocol in Unit III.B.7.d.)

16. Select an appropriate flow rate equal to or greater than 1 liter per minute (L/min) or less than 10 L/min for 25 mm cassettes. Larger filters may be operated at proportionally higher flow rates.

17. A minimum of 13 samples are to be collected for each testing site consisting of the following:

a. A minimum of five samples per abatement area.

b. A minimum of five samples per ambient area positioned at locations representative of the air entering the abatement site.

c. Two field blanks are to be taken by removing the cap for not more than 30 seconds and replacing it at the time of sampling before sampling is initiated at the following places:

i. Near the entrance to each abatement area.

ii. At one of the ambient sites. (DO NOT leave the field blanks open during the sampling period.)

d. A sealed blank is to be carried with each sample set. This representative cassette is not to be opened in the field.

18. Perform a leak check of the sampling system at each indoor and outdoor sampling site by activating the pump with the closed sampling cassette in line. Any flow indicates a leak which must be eliminated before initiating the sampling operation.

19. The following Table I specifies volume ranges to be used:

TABLE 1—NUMBER OF 200 MESH EM GRID OPENINGS (0.0057 MM^2) THAT NEED TO BE ANALYZED TO MAINTAIN SENSITIVITY OF 0.005 STRUCTURES/CC BASED ON VOLUME AND EFFECTIVE FILTER AREA

	Effective Filter Area 385 sq mm	
	Volume (liters)	# of grid openings
	560	*24*
	600	23
	700	19
	800	17
	900	15
	1,000	14
	1,100	12
Recommended Volume Range	**1,200**	**11**
	1,300	**10**
	1,400	**10**
	1,500	**9**
	1,600	**8**
	1,700	**8**
	1,800	**8**
	1,900	7
	2,000	7
	2,100	6
	2,200	6
	2,300	6
	2,400	6
	2,500	5
	2,600	5
	2,700	5
	2,800	5
	2,900	5
	3,000	5
	3,100	4
	3,200	4
	3,300	4
	3,400	4
	3,500	4
	3,600	4
	3,700	4
	3,800	4

Effective Filter Area 855 sq mm		
Volume (liters)	# of grid openings	
1,250	*24*	
1,300	23	
1,400	21	
1,600	19	
1,800	17	
2,000	15	
2,200	14	
2,400	13	
2,600	12	
2,800	**11**	Recommended Volume Range
3,000	**10**	
3,200	**9**	
3,400	**9**	
3,600	**8**	
3,800	**8**	
4,000	**8**	
4,200	7	
4,400	7	
4,600	7	
4,800	6	
5,000	6	
5,200	6	
5,400	6	
5,600	5	
5,800	5	
6,000	5	
6,200	5	
6,400	5	
6,600	5	
6,800	4	
7,000	4	
7,200	4	
7,400	4	
7,600	4	

Note minimum volumes required:
25 mm : 560 liters
37 mm : 1250 liters

Filter diameter of 25 mm = effective area of 385 sq mm
Filter diameter of 37 mm = effective area of 855 sq mm

20. Ensure that the sampler is turned upright before interrupting the pump flow.

21. Check that all samples are clearly labeled and that all pertinent information has been enclosed before transfer of the samples to the laboratory.

22. Ensure that the samples are stored in a secure and representative location.

23. Do not change containers if portions of these filters are taken for other purposes.

24. A summary of Sample Data Quality Objectives is shown in the following Table II:

TABLE II--SUMMARY OF SAMPLING AGENCY DATA QUALITY OBJECTIVES

This table summarizes the data quality objectives from the performance of this method in terms of precision, accuracy, completeness, representativeness, and comparability. These objectives are assured by the periodic control checks and reference checks listed here and described in the text of the method.

Unit Operation	QC Check	Frequency	Conformance Expectation
Sampling materials	Sealed blank	1 per I/O site	95%
Sample procedures	Field blanks	2 per I/O site	95%
	Pump calibration	Before and after each field series	90%
Sample custody	Review of chain-of-custody record	Each sample	95% complete
Sample shipment	Review of sending report	Each sample	95% complete

C. Sample Shipment

Ship bulk samples to the analytical laboratory in a separate container from air samples.

D. Sample Receiving

1. Designate one individual as sample coordinator at the laboratory. While that individual will normally be available to receive samples, the coordinator may train and supervise others in receiving procedures for those times when he/she is not available.

2. Bulk samples and air samples delivered to the analytical laboratory in the same container shall be rejected.

E. Sample Preparation

1. All sample preparation and analysis shall be performed by a laboratory independent of the abatement contractor.

2. Wet-wipe the exterior of the cassettes to minimize contamination possibilities before taking them into the clean room facility.

3. Perform sample preparation in a well-equipped clean facility.

NOTE: The clean area is required to have the following minimum characteristics. The area or hood must be capable of maintaining a positive pressure with make-up air being HEPA-filtered. The cumulative analytical blank concentration must average less than 18 s/mm^2 in an area of 0.057 mm^2 (nominally 10 200-mesh grid openings) and a single preparation with a maximum of 53 s/mm^2 for that same area.

4. Preparation areas for air samples must not only be separated from preparation areas for bulk samples, but they must be prepared in separate rooms.

5. Direct preparation techniques are required. The object is to produce an intact film containing the particulates of the filter surface which is sufficiently clear for TEM analysis.

a. TEM Grid Opening Area measurement must be done as follows:

i. The filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique.

ii. Measure 20 grid openings on each of 20 random 200-mesh copper grids by placing a grid on a glass and examining it under the PCM. Use a calibrated graticule to measure the average field diameters. From the data, calculate the field area for an average grid opening.

iii. Measurements can also be made on the TEM at a properly calibrated low magnification or on an optical microscope at a magnification of approximately 400X by using an eyepiece fitted with a scale that has been calibrated against a stage micrometer. Optical microscopy utilizing manual or automated procedures may be used providing instrument calibration can be verified.

b. TEM specimen preparation from polycarbonate (PC) filters. Procedures as described in Unit III.G. or other equivalent methods may be used.

c. TEM specimen preparation from mixed cellulose ester (MCE) filters.

i. Filter portion being used for sample preparation must have the surface collapsed using an acetone vapor technique or the Burdette procedure (Ref. 7 of Unit II.J.)

ii. Plasma etching of the collapsed filter is required. The microscope slide to which the collapsed filter pieces are attached is placed in a plasma asher. Because plasma ashers vary greatly in their performance, both from unit to unit and between different positions in the asher chamber, it is difficult to specify the conditions that should be used. Insufficient etching will result in a failure to expose embedded filters, and too much etching may result in loss of particulate from the surface. As an interim measure, it is recommended that the time for ashing of a known weight of a collapsed filter be established and that the etching rate be calculated in terms of micrometers per second. The actual etching time used for the particulate asher and operating conditions will then be set such that a 1-2 µm (10 percent) layer of collapsed surface will be removed.

iii. Procedures as described in Unit III. or other equivalent methods may be used to prepare samples.

F. TEM Method

1. An 80-120 kV TEM capable of performing electron diffraction with a fluorescent screen inscribed with calibrated gradations is required. If the TEM is equipped with EDXA it must either have a STEM attachment or be capable of producing a spot less than 250 nm in diameter at crossover. The microscope shall be calibrated routinely for magnification and camera constant.

2. *Determination of Camera Constant and ED Pattern Analysis.* The camera length of the TEM in ED operating mode must be calibrated before ED patterns on unknown samples are observed. This can be achieved by using a carbon-coated grid on which a thin film of gold has been sputtered or evaporated. A thin film of gold is evaporated on the specimen TEM grid to obtain zone-axis ED patterns superimposed with a ring pattern from the polycrystalline gold film. In practice, it is desirable to optimize the thickness of the gold film so that only one or two sharp rings are obtained on the superimposed ED pattern. Thicker gold film would normally give multiple gold rings, but it will tend to mask weaker diffraction spots from the unknown fibrous particulate. Since the unknown d-spacings of most interest in asbestos analysis are those which lie closest to the transmitted beam, multiple gold rings are unnecessary on zone-axis ED patterns. An average camera constant using multiple gold rings can be determined. The camera constant is one-half the diameter of the rings times the interplanar spacing of the ring being measured.

3. *Magnification Calibration.* The magnification calibration must be done at the fluorescent screen. The TEM must be calibrated at the grid opening magnification (if used) and also at the magnification used for fiber counting. This is performed with a cross grating replica (e.g., one containing 2,160 lines/mm). Define a field of view on the fluorescent screen either by markings or physical boundaries. The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric). A logbook must be maintained, and the dates of calibration and the values obtained must be recorded. The frequency of calibration depends on the past history of the particular microscope. After any maintenance of the microscope that involved adjustment of the power supplied to the lenses or the high-voltage system or the mechanical disassembly of the electron optical column apart from filament exchange, the magnification must be recalibrated. Before the TEM calibration is performed, the analyst must ensure that the cross grating replica is placed at the same distance from the objective lens as the specimens are. For instruments that incorporate a eucentric tilting specimen stage, all specimens and the cross grating replica must be placed at the eucentric position.

4. While not required on every microscope in the laboratory, the laboratory must have either one microscope equipped with energy dispersive X-ray analysis or access to an equivalent system on a TEM in another laboratory.

5. Microscope settings: 80-120 kV, grid assessment 250-1,000X, then 15,000-20,000X screen magnification for analysis.

6. Approximately one-half (0.5) of the predetermined sample area to be analyzed shall be performed on one sample grid preparation and the remaining half on a second sample grid preparation.

7. Individual grid openings with greater than 5 percent openings (holes) or covered with greater than 25 percent particulate matter or obviously having nonuniform loading must not be analyzed.

8. Reject the grid if:

a. Less than 50 percent of the grid openings covered by the replica are intact.

b. The replica is doubled or folded.

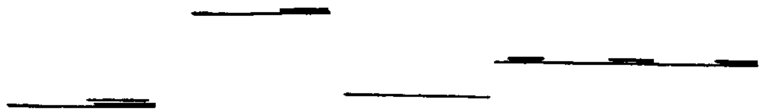
c. The replica is too dark because of incomplete dissolution of the filter.

9. *Recording Rules.*

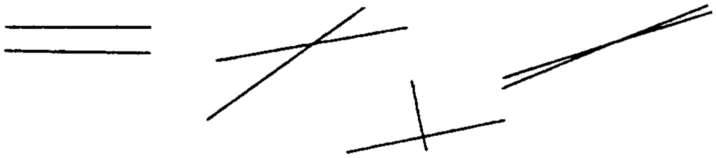
a. Any continuous grouping of particles in which an asbestos fiber with an aspect ratio greater than or equal to 5:1 and a length greater than or equal to 0.5 µm is detected shall be recorded on the count sheet. These will be designated asbestos structures and will be classified as fibers, bundles, clusters, or matrices. Record as individual fibers any contiguous grouping having 0, 1, or 2 definable intersections. Groupings having more than 2 intersections are to be described as cluster or matrix. An intersection is a nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater. See the following Figure 2:

FIGURE 2--COUNTING GUIDELINES USED IN DETERMINING ASBESTOS STRUCTURES

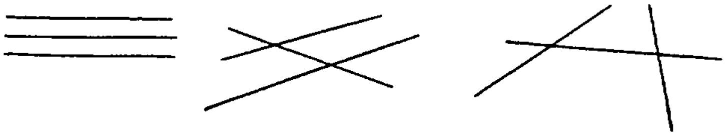
Count as 1 fiber; 1 Structure; no intersections.



Count as 2 fibers if space between fibers is greater than width of 1 fiber diameter or number of intersections is equal to or less than 1.

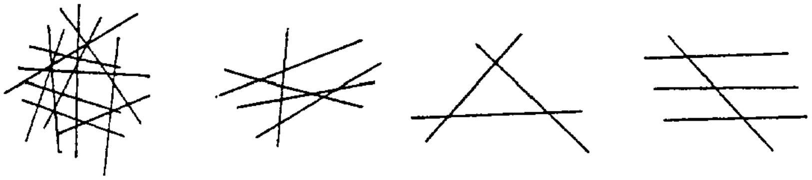


Count as 3 structures if space between fibers is greater than width of 1 fiber diameter or if the number of intersections is equal to or less than 2.

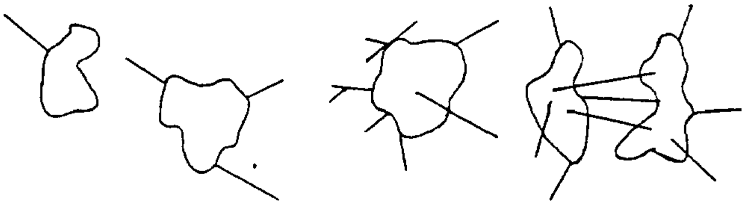


Count bundles as 1 structure; 3 or more parallel fibrils less than 1 fiber diameter separation.

Count clusters as 1 structure; fibers having greater than or equal to 3 intersections.



Count matrix as 1 structure.



DO NOT COUNT AS STRUCTURES:

Fiber protrusion
<5:1 Aspect Ratio

No fiber protusion

Fiber protrusion
<0.5 micrometer

— <0.5 micrometer in length
▬ <5:1 Aspect Ratio

i. *Fiber.* A structure having a minimum length greater than or equal to 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

ii. *Bundle.* A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

iii. *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

iv. *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

b. Separate categories will be maintained for fibers less than 5 µm and for fibers equal to or greater than 5 µm in length.

c. Record NSD when no structures are detected in the field.

d. Visual identification of electron diffraction (ED) patterns is required for each asbestos structure counted which would cause the analysis to exceed the 70 s/mm² concentration. (Generally this means the first four fibers identified as asbestos must exhibit an identifiable diffraction pattern for chrysotile or amphibole.)

e. The micrograph number of the recorded diffraction patterns must be reported to the client and maintained in the laboratory's quality assurance records. In the event that examination of the pattern by a qualified individual indicates that the pattern has been misidentified visually, the client shall be contacted.

f. Energy Dispersive X-ray Analysis (EDXA) is required of all amphiboles which would cause the analysis results to exceed the 70 s/mm² concentration. (Generally speaking, the first 4 amphiboles would require EDXA.)

g. If the number of fibers in the nonasbestos class would cause the analysis to exceed the 70 s/mm² concentration, the fact that they are not asbestos must be confirmed by EDXA or measurement of a zone axis diffraction pattern.

h. Fibers classified as chrysotile must be identified by diffraction or X-ray analysis and recorded on a count sheet. X-ray analysis alone can be used only after 70 s/mm² have been exceeded for a particular sample.

i. Fibers classified as amphiboles must be identified by X-ray analysis and electron diffraction and recorded on the count sheet. (X-ray analysis alone can be used only after 70 s/mm² have been exceeded for a particular sample.)

j. If a diffraction pattern was recorded on film, record the micrograph number on the count sheet.

k. If an electron diffraction was attempted but no pattern was observed, record N on the count sheet.

l. If an EDXA spectrum was attempted but not observed, record N on the count sheet.

m. If an X-ray analysis spectrum is stored, record the file and disk number on the count sheet.

10. Classification Rules.

a. *Fiber.* A structure having a minimum length greater than or equal to 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

b. *Bundle.* A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

c. *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

d. *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

11. After finishing with a grid, remove it from the microscope, and replace it in the appropriate grid holder. Sample grids must be stored for a minimum of 1 year from the date of the analysis; the sample cassette must be retained for a minimum of 30 days by the laboratory or returned at the client's request.

G. Sample Analytical Sequence

1. Under the present sampling requirements a minimum of 13 samples is to be collected for the clearance testing of an abatement site. These include five abatement area samples, five ambient samples, two field blanks, and one sealed blank.

2. Carry out visual inspection of work site prior to air monitoring.

3. Collect a minimum of 5 air samples inside the work site and 5 samples outside the work site. The indoor and outdoor samples shall be taken during the same time period.

4. Remaining steps in the analytical sequence are contained in Unit IV of this Appendix.

H. Reporting

1. The following information must be reported to the client for each sample analyzed:

a. Concentration in structures per square millimeter and structures per cubic centimeter.

b. Analytical sensitivity used for the analysis.

c. Number of asbestos structures.

d. Area analyzed.

e. Volume of air sampled (which must be initially supplied to lab by client).

f. Copy of the count sheet must be included with the report.

g. Signature of laboratory official to indicate that the laboratory met specifications of the method.

h. Report form must contain official laboratory identification (e.g., letterhead).

i. Type of asbestos.

I. Quality Control/Quality Assurance Procedures (Data Quality Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards are to be performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the following Table III:

TABLE III--SUMMARY OF LABORATORY DATA QUALITY OBJECTIVES

Unit Operation	QC Check	Frequency	Conformance Expectation
Sample receiving	Review of receiving report	Each sample	95% complete
Sample custody	Review of chain-of-custody record	Each sample	95% complete
Sample preparation	Supplies and reagents	On receipt	Meet specs. or reject
	Grid opening size	20 openings/20 grids/lot of 1000 or 1 opening/sample	100%
	Special clean area monitoring	After cleaning or service	Meet specs or reclean
	Laboratory blank	1 per prep series or 10%	Meet specs. or reanalyze series
	Plasma etch blank	1 per 20 samples	75%
	Multiple preps (3 per sample)	Each sample	One with cover of 15 complete grid sqs.
Sample analysis	System check	Each day	Each day
	Alignment check	Each day	Each day
	Magnification calibration with low and high standards	Each month or after service	95%
	ED calibration by gold standard	Weekly	95%
	EDS calibration by copper line	Daily	95%
Performance check	Laboratory blank (measure of cleanliness)	Prep 1 per series or 10% read 1 per 25 samples	Meet specs or reanalyze series
	Replicate counting (measure of precision)	1 per 100 samples	1.5 x Poisson Std. Dev.
	Duplicate analysis (measure of reproducibility)	1 per 100 samples	2 x Poisson Std. Dev.
	Known samples of typical materials (working standards)	Training and for comparison with unknowns	100%
	Analysis of NBS SRM 1876 and/or RM 8410 (measure of accuracy and comparability)	1 per analyst per year	1.5 x Poisson Std. Dev.
	Data entry review (data validation and measure of completeness)	Each sample	95%
	Record and verify ID electron diffraction pattern of structure	1 per 5 samples	80% accuracy
Calculations and data reduction	Hand calculation of automated data reduction procedure or independent recalculation of hand-calculated data	1 per 100 samples	85%

1. When the samples arrive at the laboratory, check the samples and documentation for completeness and requirements before initiating the analysis.

2. Check all laboratory reagents and supplies for acceptable asbestos background levels.

3. Conduct all sample preparation in a clean room environment monitored by laboratory blanks. Testing with blanks must also be done after cleaning or servicing the room.

4. Prepare multiple grids of each sample.

5. Provide laboratory blanks with each sample batch. Maintain a cumulative average of these results. If there are more than 53 fibers/mm^2 per 10 200-mesh grid openings, the system must be checked for possible sources of contamination.

6. Perform a system check on the transmission electron microscope daily.

7. Make periodic performance checks of magnification, electron diffraction and energy dispersive X-ray systems as set forth in Table III under Unit II.I.

8. Ensure qualified operator performance by evaluation of replicate analysis and standard sample comparisons as set forth in Table III under Unit II.I.

9. Validate all data entries.

10. Recalculate a percentage of all computations and automatic data reduction steps as specified in Table III under Unit II.I.

11. Record an electron diffraction pattern of one asbestos structure from every five samples that contain asbestos. Verify the identification of the pattern by measurement or comparison of the pattern with patterns collected from standards under the same conditions. The records must also demonstrate that the identification of the pattern has been verified by a qualified individual and that the operator who made the identification is maintaining at least an 80 percent correct visual identification based on his measured patterns.

12. Appropriate logs or records must be maintained by the analytical laboratory verifying that it is in compliance with the mandatory quality assurance procedures.

J. References

For additional background information on this method, the following references should be consulted.

1. "Guidance for Controlling Asbestos-Containing Materials in Buildings," EPA 560/5-85-024, June 1985.

2. "Measuring Airborne Asbestos Following an Abatement Action," USEPA, Office of Pollution Prevention and Toxics, EPA 600/4-85-049, 1985.

3. Small, John and E. Steel. Asbestos Standards: Materials and Analytical Methods. N.B.S. Special Publication 619, 1982.

4. Campbell, W.J., R.L. Blake, L.L. Brown, E.E. Cather, and J.J. Sjoberg. Selected Silicate Minerals and Their Asbestiform Varieties. Information Circular 8751, U.S. Bureau of Mines, 1977.

5. Quality Assurance Handbook for Air Pollution Measurement System. Ambient Air Methods. EPA 600/4-77-027a, USEPA, Office of Research and Development, 1977.

6. Method 2A: Direct Measurement of Gas Volume through Pipes and Small Ducts. 40 CFR Part 60 Appendix A.

7. Burdette, G.J., Health & Safety Exec. Research & Lab. Services Div., London, "Proposed Analytical Method for Determination of Asbestos in Air."

8. Chatfield, E.J., Chatfield Tech. Cons., Ltd., Clark, T., PEI Assoc., "Standard Operating Procedure for Determination of Airborne Asbestos Fibers by Transmission Electron Microscopy Using Polycarbonate Membrane Filters," WERL SOP 87-1, March 5, 1987.

9. NIOSH Method 7402 for Asbestos Fibers, 12-11-86 Draft.

10. Yamate, G., Agarwall, S.C., Gibbons, R.D., IIT Research Institute, "Methodology for the Measurement of Airborne Asbestos by Electron Microscopy," Draft report, USEPA Contract 68-02-3266, July 1984.

11. "Guidance to the Preparation of Quality Assurance Project Plans," USEPA, Office of Pollution Prevention and Toxics, 1984.

III. Nonmandatory Transmission Electron Microscopy Method

A. Definitions of Terms

1. *Analytical sensitivity*—Airborne asbestos concentration represented by each fiber counted under the electron microscope. It is determined by the air volume collected and the proportion of the filter examined. This method requires that the analytical sensitivity be no greater than 0.005 s/cm^3.

2. *Asbestiform*—A specific type of mineral fibrosity in which the fibers and fibrils possess high tensile strength and flexibility.

3. *Aspect ratio*—A ratio of the length to the width of a particle. Minimum aspect ratio as defined by this method is equal to or greater than 5:1.

4. *Bundle*—A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

5. *Clean area*—A controlled environment which is maintained and monitored to assure a low probability of asbestos contamination to materials in that space. Clean areas used in this method have HEPA filtered air under positive pressure and are capable of sustained operation with an open laboratory blank which on subsequent analysis has an average of less than 18 structures/mm^2 in an area of 0.057 mm^2 (nominally 10 200 mesh grid openings) and a maximum of 53 structures/mm^2 for no more than one single preparation for that same area.

6. *Cluster*—A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

7. *ED*—Electron diffraction.

8. *EDXA*—Energy dispersive X-ray analysis.

9. *Fiber*—A structure greater than or equal to 0.5 µm in length with an aspect ratio (length to width) of 5:1 or greater and having substantially parallel sides.

10. *Grid*—An open structure for mounting on the sample to aid in its examination in the TEM. The term is used here to denote a 200-mesh copper lattice approximately 3 mm in diameter.

11. *Intersection*—Nonparallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater.

12. *Laboratory sample coordinator*—That person responsible for the conduct of sample handling and the certification of the testing procedures.

13. *Filter background level*—The concentration of structures per square millimeter of filter that is considered indistinguishable from the concentration measured on blanks (filters through which no air has been drawn). For this method the filter background level is defined as 70 structures/mm^2.

14. *Matrix*—Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

15. *NSD*—No structure detected.

16. *Operator*—A person responsible for the TEM instrumental analysis of the sample.

17. *PCM*—Phase contrast microscopy.

18. *SAED*—Selected area electron diffraction.

19. *SEM*—Scanning electron microscope.

20. *STEM*—Scanning transmission electron microscope.

21. *Structure*—a microscopic bundle, cluster, fiber, or matrix which may contain asbestos.

22. *S/cm^3*—Structures per cubic centimeter.

23. *S/mm^2*—Structures per square millimeter.

24. *TEM*—Transmission electron microscope.

B. Sampling

1. Sampling operations must be performed by qualified individuals completely independent of the abatement contractor to avoid possible conflict of interest (See References 1, 2, and 5 of Unit III.L.) Special precautions should be taken to avoid contamination of the sample. For example, materials that have not been prescreened for their asbestos background content should not be used; also, sample handling procedures which do not take cross contamination possibilities into account should not be used.

2. Material and supply checks for asbestos contamination should be made on all critical supplies, reagents, and procedures before their use in a monitoring study.

3. Quality control and quality assurance steps are needed to identify problem areas and isolate the cause of the contamination (see Reference 5 of Unit III.L.). Control checks shall be permanently recorded to document the quality of the information produced. The sampling firm must have written quality control procedures and documents which verify compliance. Independent audits by a qualified consultant or firm should be performed once a year. All documentation of compliance should be retained indefinitely to provide a guarantee of quality. A summary of Sample Data Quality Objectives is shown in Table II of Unit II.B.

4. Sampling materials.

a. Sample for airborne asbestos following an abatement action using commercially available cassettes.

b. Use either a cowling or a filter-retaining middle piece. Conductive material may reduce the potential for particulates to adhere to the walls of the cowl.

c. Cassettes must be verified as "clean" prior to use in the field. If packaged filters are used for loading or preloaded cassettes are purchased from the manufacturer or a distributor, the manufacturer's name and lot number should be entered on all field data sheets provided to the laboratory, and are required to be listed on all reports from the laboratory.

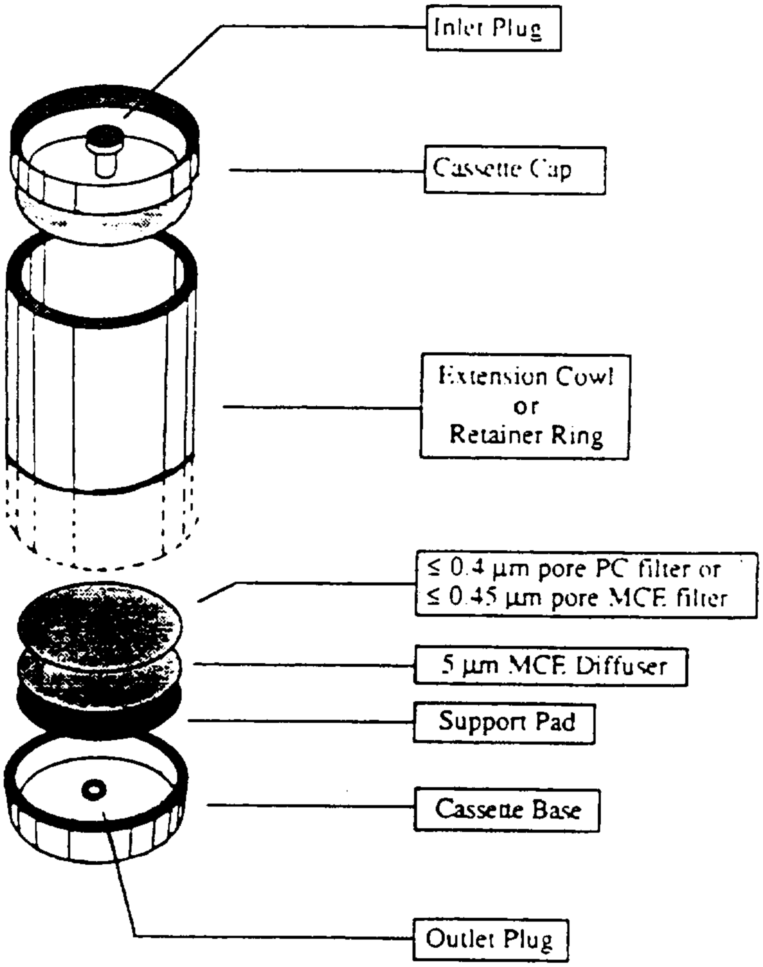
d. Assemble the cassettes in a clean facility (See definition of clean area under Unit III.A.).

e. Reloading of used cassettes is not permitted.

f. Use sample collection filters which are either polycarbonate having a pore size of less than or equal to 0.4 µm or mixed cellulose ester having a pore size of less than or equal to 0.45 µm.

g. Place these filters in series with a backup filter with a pore size of 5.0 µm (to serve as a diffuser) and a support pad. See the following Figure 1:

FIGURE I--SAMPLING CASSETTE CONFIGURATION



h. When polycarbonate filters are used, position the highly reflective face such that the incoming particulate is received on this surface

i. Seal the cassettes to prevent leakage around the filter edges or between cassette part joints. A mechanical press may be useful to achieve a reproducible leak-free seal.

Shrink fit gel-bands may be used for this purpose and are available from filter manufacturers and their authorized distributors.

j. Use wrinkle-free loaded cassettes in the sampling operation.

5. Pump setup.

a. Calibrate the sampling pump over the range of flow rates and loads anticipated for the monitoring period with this flow measuring device in series. Perform this calibration using guidance from EPA Method 2A each time the unit is sent to the field (See Reference 6 of Unit III.L.).

b. Configure the sampling system to preclude pump vibrations from being transmitted to the cassette by using a sampling stand separate from the pump station and making connections with flexible tubing.

c. Maintain continuous smooth flow conditions by damping out any pump action fluctuations if necessary.

d. Check the sampling system for leaks with the end cap still in place and the pump operating before initiating sample collection. Trace and stop the source of any flow indicated by the flowmeter under these conditions.

e. Select an appropriate flow rate equal to or greater than 1 L/min or less than 10 L/min for 25 mm cassettes. Larger filters may be operated at proportionally higher flow rates.

f. Orient the cassette downward at approximately 45 degrees from the horizontal.

g. Maintain a log of all pertinent sampling information, such as pump identification number, calibration data, sample location, date, sample identification number, flow rates at the beginning, middle, and end, start and stop times, and other useful information or comments. Use of a sampling log form is recommended. See the following Figure 2:

FIGURE 2--SAMPLING LOG FORM

Sample Number	Location of Sample	Pump I.D.	Start Time	Middle Time	End Time	Flow Rate

Inspector: ______________________ Date: ______________

h. Initiate a chain of custody procedure at the start of each sampling, if this is requested by the client.

i. Maintain a close check of all aspects of the sampling operation on a regular basis.

j. Continue sampling until at least the minimum volume is collected, as specified in the following Table I:

TABLE 1--NUMBER OF 200 MESH EM GRID OPENINGS ($0.0057\ MM^2$) THAT NEED TO BE ANALYZED TO MAINTAIN SENSITIVITY OF 0.005 STRUCTURES/CC BASED ON VOLUME AND EFFECTIVE FILTER AREA

Effective Filter Area 385 sq mm

	Volume (liters)	# of grid openings
	560	*24*
	600	23
	700	19
	800	17
	900	15
	1,000	14
	1,100	12
Recommended Volume Range	1,200	11
	1,300	10
	1,400	10
	1,500	9
	1,600	8
	1,700	8
	1,800	8
	1,900	7
	2,000	7
	2,100	6
	2,200	6
	2,300	6
	2,400	6
	2,500	5
	2,600	5
	2,700	5
	2,800	5
	2,900	5
	3,000	5
	3,100	4
	3,200	4
	3,300	4
	3,400	4
	3,500	4
	3,600	4
	3,700	4
	3,800	4

Effective Filter Area 855 sq mm

Volume (liters)	# of grid openings	
1,250	*24*	
1,300	23	
1,400	21	
1,600	19	
1,800	17	
2,000	15	
2,200	14	
2,400	13	
2,600	12	
2,800	11	Recommended Volume Range
3,000	10	
3,200	9	
3,400	9	
3,600	8	
3,800	8	
4,000	8	
4,200	7	
4,400	7	
4,600	7	
4,800	6	
5,000	6	
5,200	6	
5,400	6	
5,600	5	
5,800	5	
6,000	5	
6,200	5	
6,400	5	
6,600	5	
6,800	4	
7,000	4	
7,200	4	
7,400	4	
7,600	4	

Note minimum volumes required:
25 mm : 560 liters
37 mm : 1250 liters

Filter diameter of 25 mm = effective area of 385 sq mm
Filter diameter of 37 mm = effective area of 855 sq mm

k. At the conclusion of sampling, turn the cassette upward before stopping the flow to minimize possible particle loss. If the sampling is resumed, restart the flow before reorienting the cassette downward. Note the condition of the filter at the conclusion of sampling.

l. Double check to see that all information has been recorded on the data collection forms and that the cassette is securely closed and appropriately identified using a waterproof label. Protect cassettes in individual clean resealed polyethylene bags. Bags are to be used for storing cassette caps when they are removed for sampling purposes. Caps and plugs should only be removed or replaced using clean hands or clean disposable plastic gloves.

m. Do not change containers if portions of these filters are taken for other purposes.

6. Minimum sample number per site. A minimum of 13 samples are to be collected for each testing consisting of the following:

a. A minimum of five samples per abatement area.

b. A minimum of five samples per ambient area positioned at locations representative of the air entering the abatement site.

c. Two field blanks are to be taken by removing the cap for not more than 30 sec and replacing it at the time of sampling before sampling is initiated at the following places:

i. Near the entrance to each ambient area.

ii. At one of the ambient sites.

(NOTE: Do not leave the blank open during the sampling period.)

d. A sealed blank is to be carried with each sample set. This representative cassette is not to be opened in the field.

7. Abatement area sampling.

a. Conduct final clearance sampling only after the primary containment barriers have been removed; the abatement area has been thoroughly dried; and, it has passed visual inspection tests by qualified personnel. (See Reference 1 of Unit III.L.)

b. Containment barriers over windows, doors, and air passageways must remain in place until the TEM clearance sampling and analysis is completed and results meet clearance test criteria. The final plastic barrier remains in place for the sampling period.

c. Select sampling sites in the abatement area on a random basis to provide unbiased and representative samples.

d. After the area has passed a thorough visual inspection, use aggressive sampling conditions to dislodge any remaining dust.

i. Equipment used in aggressive sampling such as a leaf blower and/or fan should be properly cleaned and decontaminated before use.

ii. Air filtration units shall remain on during the air monitoring period.

iii. Prior to air monitoring, floors, ceiling and walls shall be swept with the exhaust of a minimum one (1) horsepower leaf blower.

iv. Stationary fans are placed in locations which will not interfere with air monitoring equipment. Fan air is directed toward the ceiling. One fan shall be used for each 10.000 ft^3 of worksite.

v. Monitoring of an abatement work area with high-volume pumps and the use of circulating fans will require electrical power. Electrical outlets in the abatement area may be used if available. If no such outlets are available, the equipment must be supplied with electricity by the use of extension cords and strip plug units. All electrical power supply equipment of this type must be approved Underwriter Laboratory equipment that has not been modified. All wiring must be grounded. Ground fault interrupters should be used. Extreme care must be taken to clean up any residual water and ensure that electrical equipment does not become wet while operational.

vi. Low volume pumps may be carefully wrapped in 6-mil polyethylene to insulate the pump from the air. High volume pumps cannot be sealed in this manner since the heat of the motor may melt the plastic. The pump exhausts should be kept free.

vii. If recleaning is necessary, removal of this equipment from the work area must be handled with care. It is not possible to completely decontaminate the pump motor and parts since these areas cannot be wetted. To minimize any problems in this area, all equipment such as fans and pumps should be carefully wet wiped prior to removal from the abatement area. Wrapping and sealing low volume pumps in 6-mil polyethylene will provide easier decontamination of this equipment. Use of clean water and disposable wipes should be available for this purpose.

e. Pump flow rate equal to or greater than 1 L/min or less than 10 L/min may be used for 25 mm cassettes. The larger cassette diameters may have comparably increased flow.

f. Sample a volume of air sufficient to ensure the minimum quantitation limits. (See Table I of Unit III.B.5.j.)

8. Ambient sampling.

a. Position ambient samplers at locations representative of the air entering the abatement site. If makeup air entering the abatement site is drawn from another area of the building which is outside of the abatement area, place the pumps in the building, pumps should be placed out of doors located near the building and away from any obstructions that may influence wind patterns. If construction is in progress immediately outside the enclosure, it may be necessary to select another ambient site. Samples should be representative of any air entering the work site.

b. Locate the ambient samplers at least 3 ft apart and protect them from adverse weather conditions.

c. Sample same volume of air as samples taken inside the abatement site.

C. Sample Shipment

1. Ship bulk samples in a separate container from air samples. Bulk samples and air samples delivered to the analytical laboratory in the same container shall be rejected.

2. Select a rigid shipping container and pack the cassettes upright in a noncontaminating nonfibrous medium such as a bubble pack. The use of resealable polyethylene bags may help to prevent jostling of individual cassettes.

3. Avoid using expanded polystyrene because of its static charge potential. Also avoid using particle-based packaging materials because of possible contamination.

4. Include a shipping bill and a detailed listing of samples shipped, their descriptions

and all identifying numbers or marks, sampling data, shipper's name, and contact information. For each sample set, designate which are the ambient samples, which are the abatement area samples, which are the field blanks, and which is the sealed blank if sequential analysis is to be performed.

5. Hand-carry samples to the laboratory in an upright position if possible; otherwise choose that mode of transportation least likely to jar the samples in transit.

6. Address the package to the laboratory sample coordinator by name when known and alert him or her of the package description, shipment mode, and anticipated arrival as part of the chain of custody and sample tracking procedures. This will also help the laboratory schedule timely analysis for the samples when they are received.

D. Quality Control/Quality Assurance Procedures (Data Quality Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards is performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined, and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the text below.

1. Prescreen the loaded cassette collection filters to assure that they do not contain concentrations of asbestos which may interfere with the analysis of the sample. A filter blank average of less than 18 s/mm^2 in an area of 0.057 mm^2 (nominally 10 200-mesh grid openings) and a maximum of 53 s/mm^2 for that same area for any single preparation is acceptable for this method.

2. Calibrate sampling pumps and their flow indicators over the range of their intended use with a recognized standard. Assemble the sampling system with a representative filter—not the filter which will be used in sampling—before and after the sampling operation.

3. Record all calibration information with the data to be used on a standard sampling form.

4. Ensure that the samples are stored in a secure and representative location.

5. Ensure that mechanical calibrations from the pump will be minimized to prevent transferral of vibration to the cassette.

6. Ensure that a continuous smooth flow of negative pressure is delivered by the pump by installing a damping chamber if necessary.

7. Open a loaded cassette momentarily at one of the indoor sampling sites when sampling is initiated. This sample will serve as an indoor field blank.

8. Open a loaded cassette momentarily at one of the outdoor sampling sites when sampling is initiated. This sample will serve as an outdoor field blank.

9. Carry a sealed blank into the field with each sample series. Do not open this cassette in the field.

10. Perform a leak check of the sampling system at each indoor and outdoor sampling site by activating the pump with the closed sampling cassette in line. Any flow indicates a leak which must be eliminated before initiating the sampling operation.

11. Ensure that the sampler is turned upright before interrupting the pump flow.

12. Check that all samples are clearly labeled and that all pertinent information has been enclosed before transfer of the samples to the laboratory.

E. Sample Receiving

1. Designate one individual as sample coordinator at the laboratory. While that individual will normally be available to receive samples, the coordinator may train and supervise others in receiving procedures for those times when he/she is not available.

2. Adhere to the following procedures to ensure both the continued chain-of-custody and the accountability of all samples passing through the laboratory:

a. Note the condition of the shipping package and data written on it upon receipt.

b. Retain all bills of lading or shipping slips to document the shipper and delivery time.

c. Examine the chain-of-custody seal, if any, and the package for its integrity.

d. If there has been a break in the seal or substantive damage to the package, the sample coordinator shall immediately notify the shipper and a responsible laboratory manager before any action is taken to unpack the shipment.

e. Packages with significant damage shall be accepted only by the responsible laboratory manager after discussions with the client.

3. Unwrap the shipment in a clean, uncluttered facility. The sample coordinator or his or her designee will record the contents, including a description of each item and all identifying numbers or marks. A

Sample Receiving Form to document this information is attached for use when necessary. (See the following Figure 3.)

FIGURE 3--SAMPLE RECEIVING FORM

Date of package delivery ____________ Package shipped from ________________

Carrier ______________________ Shipping bill retained ______________

*Condition of package on receipt____

*Condition of custody seal ____

Number of samples received __________ Shipping manifest attached ___________

Purchase Order No. ______________ Project I.D. ____________________

Comments ____

No.	Description	Sampling Medium		Sampled Volume Liters	Receiving ID #	Assigned #
		PC	MCE			
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

(Use as many additional sheets as needed.)

Comments ____

Date of acceptance into sample bank _____________________________

Signature of chain-of-custody recipient __________________________

Disposition of samples____

*Note: If the package has sustained substantial damage or the custody seal is broken, stop and contact the project manager and the shipper.

NOTE: The person breaking the chain-of-custody seal and itemizing the contents assumes responsibility for the shipment and signs documents accordingly.

4. Assign a laboratory number and schedule an analysis sequence.

5. Manage all chain-of-custody samples within the laboratory such that their integrity can be ensured and documented.

F. Sample Preparation

1. Personnel not affiliated with the Abatement Contractor shall be used to prepare samples and conduct TEM analysis. Wet-wipe the exterior of the cassettes to minimize contamination possibilities before taking them to the clean sample preparation facility.

2. Perform sample preparation in a well-equipped clean facility.

NOTE: The clean area is required to have the following minimum characteristics. The area or hood must be capable of maintaining a positive pressure with make-up air being HEPA filtered. The cumulative analytical blank concentration must average less than 18 s/mm^2 in an area of 0.057 s/mm^2 (nominally 10 200-mesh grid openings) with no more than one single preparation to exceed 53 s/mm^2 for that same area.

3. Preparation areas for air samples must be separated from preparation areas for bulk samples. Personnel must not prepare air samples if they have previously been preparing bulk samples without performing appropriate personal hygiene procedures, i.e., clothing change, showering, etc.

4. *Preparation.* Direct preparation techniques are required. The objective is to produce an intact carbon film containing the particulates from the filter surface which is sufficiently clear for TEM analysis. Currently recommended direct preparation procedures for polycarbonate (PC) and mixed cellulose ester (MCE) filters are described in Unit III.F.7. and 8. Sample preparation is a subject requiring additional research. Variation on those steps which do not substantively change the procedure, which improve filter clearing or which reduce contamination problems in a laboratory are permitted.

a. Use only TEM grids that have had grid opening areas measured according to directions in Unit III.J.

b. Remove the inlet and outlet plugs prior to opening the cassette to minimize any pressure differential that may be present.

c. Examples of techniques used to prepare polycarbonate filters are described in Unit III.F.7.

d. Examples of techniques used to prepare mixed cellulose ester filters are described in Unit III.F.8.

e. Prepare multiple grids for each sample.

f. Store the three grids to be measured in appropriately labeled grid holders or polyethylene capsules.

5. Equipment.

a. Clean area.

b. Tweezers. Fine-point tweezers for handling of filters and TEM grids.

c. Scalpel Holder and Curved No. 10 Surgical Blades.

d. Microscope slides.

e. Double-coated adhesive tape.

f. Gummed page reinforcements.

g. Micro-pipet with disposal tips 10 to 100 μL variable volume.

h. Vacuum coating unit with facilities for evaporation of carbon. Use of a liquid nitrogen cold trap above the diffusion pump will minimize the possibility of contamination of the filter surface by oil from the pumping system. The vacuum-coating unit can also be used for deposition of a thin film of gold.

i. *Carbon rod electrodes.* Spectrochemically pure carbon rods are required for use in the vacuum evaporator for carbon coating of filters.

j. *Carbon rod sharpener.* This is used to sharpen carbon rods to a neck. The use of necked carbon rods (or equivalent) allows the carbon to be applied to the filters with a minimum of heating.

k. *Low-temperature plasma asher.* This is used to etch the surface of collapsed mixed cellulose ester (MCE) filters. The asher should be supplied with oxygen, and should be modified as necessary to provide a throttle or bleed valve to control the speed of the vacuum to minimize disturbance of the filter. Some early models of ashers admit air too rapidly, which may disturb particulates on the surface of the filter during the etching step.

l. *Glass petri dishes, 10 cm in diameter, 1 cm high.* For prevention of excessive evaporation of solvent when these are in use, a good seal must be provided between the base and the lid. The seal can be improved by grinding the base and lid together with an abrasive grinding material.

m. Stainless steel mesh.

n. Lens tissue.

o. Copper 200-mesh TEM grids, 3 mm in diameter, or equivalent.

p. Gold 200-mesh TEM grids, 3 mm in diameter, or equivalent.

q. Condensation washer.

r. Carbon-coated, 200-mesh TEM grids, or equivalent.

s. Analytical balance, 0.1 mg sensitivity.

t. Filter paper, 9 cm in diameter.

u. Oven or slide warmer. Must be capable of maintaining a temperature of 65-70 °C.

v. Polyurethane foam, 6 mm thickness.

w. Gold wire for evaporation.

6. Reagents.

a. *General.* A supply of ultra-clean, fiber-free water must be available for washing of all components used in the analysis. Water that has been distilled in glass or filtered or deionized water is satisfactory for this purpose. Reagents must be fiber-free.

b. Polycarbonate preparation method—chloroform.

c. Mixed Cellulose Ester (MCE) preparation method—acetone or the Burdette procedure (Ref. 7 of Unit III.L.).

7. TEM specimen preparation from polycarbonate filters.

a. *Specimen preparation laboratory.* It is most important to ensure that contamination of TEM specimens by extraneous asbestos fibers is minimized during preparation.

b. Cleaning of sample cassettes. Upon receipt at the analytical laboratory and before they are taken into the clean facility or laminar flow hood, the sample cassettes must be cleaned of any contamination adhering to the outside surfaces.

c. Preparation of the carbon evaporator. If the polycarbonate filter has already been carbon-coated prior to receipt, the carbon coating step will be omitted, unless the analyst believes the carbon film is too thin. If there is a need to apply more carbon, the filter will be treated in the same way as an uncoated filter. Carbon coating must be performed with a high-vacuum coating unit. Units that are based on evaporation of carbon filaments in a vacuum generated only by an oil rotary pump have not been evaluated for this application, and must not be used. The carbon rods should be sharpened by a carbon rod sharpener to necks of about 4 mm long and 1 mm in diameter. The rods are installed in the evaporator in such a manner that the points are approximately 10 to 12 cm from the surface of a microscope slide held in the rotating and tilting device.

d. Selection of filter area for carbon coating. Before preparation of the filters, a 75 mm x 50 mm microscope slide is washed and dried. This slide is used to support strips of filter during the carbon evaporation. Two parallel strips of double-sided adhesive tape are applied along the length of the slide. Polycarbonate filters are easily stretched during handling, and cutting of areas for further preparation must be performed with great care. The filter and the MCE backing filter are removed together from the cassette and placed on a cleaned glass microscope slide. The filter can be cut with a curved scalpel blade by rocking the blade from the point placed in contact with the filter. The process can be repeated to cut a strip approximately 3 mm wide across the diameter of the filter. The strip of polycarbonate filter is separated from the corresponding strip of backing filter and carefully placed so that it bridges the gap between the adhesive tape strips on the microscope slide. The filter strip can be held with fine-point tweezers and supported underneath by the scalpel blade during placement on the microscope slide. The analyst can place several such strips on the same microscope slide, taking care to rinse and wet-wipe the scalpel blade and tweezers before handling a new sample. The filter strips should be identified by etching the glass slide or marking the slide using a marker insoluble in water and solvents. After the filter strip has been cut from each filter, the residual parts of the filter must be returned to the cassette and held in position by reassembly of the cassette. The cassette will then be archived for a period of 30 days or returned to the client upon request.

e. Carbon coating of filter strips. The glass slide holding the filter strips is placed on the rotation-tilting device, and the evaporator chamber is evacuated. The evaporation must be performed in very short bursts, separated by some seconds to allow the electrodes to cool. If evaporation is too rapid, the strips of polycarbonate filter will begin to curl, which will lead to cross-linking of the surface material and make it relatively insoluble in chloroform. An experienced analyst can judge the thickness of carbon film to be applied, and some test should be made first on unused filters. If the film is too thin, large particles will be lost from the TEM specimen, and there will be few complete and undamaged grid openings on the specimen. If the coating is too thick, the filter will tend to curl when exposed to chloroform vapor and the carbon film may not adhere to the support mesh. Too thick a carbon film will also lead to a TEM image that is lacking in contrast, and the ability to obtain ED patterns will be compromised. The carbon film should be as thin as possible and remain intact on most of the grid openings of the TEM specimen intact.

f. Preparation of the Jaffe washer. The precise design of the Jaffe washer is not considered important, so any one of the published designs may be used. A washer consisting of a simple stainless steel bridge is recommended. Several pieces of lens tissue approximately 1.0 cm x 0.5 cm are placed on the stainless steel bridge, and the washer is filled with chloroform to a level where the meniscus contacts the underside of the mesh, which results in saturation of the lens tissue. See References 8 and 10 of Unit III.L.

g. Placing of specimens into the Jaffe washer. The TEM grids are first placed on a piece of lens tissue so that individual grids can be picked up with tweezers. Using a curved scalpel blade, the analyst excises three 3 mm square pieces of the carbon-coated polycarbonate filter from the filter strip. The three squares are selected from the center of the strip and from two points between the outer periphery of the active surface and the center. The piece of filter is placed on a TEM specimen grid with the shiny side of the TEM grid facing upwards, and the whole assembly is placed boldly onto the saturated lens tissue in the Jaffe washer. If carbon-coated grids are used, the filter should be placed carbon-coated side down. The three excised squares of filters are placed on the same piece of lens tissue. Any number of separate pieces of lens tissue may be placed in the same Jaffe washer. The lid is then placed on the Jaffe washer, and the system is allowed to stand for several hours, preferably overnight.

h. *Condensation washing.* It has been found that many polycarbonate filters will not dissolve completely in the Jaffe washer, even after being exposed to chloroform for as long as 3 days. This problem becomes more serious if the surface of the filter was overheated during the carbon evaporation. The presence of undissolved filter medium on the TEM preparation leads to partial or complete obscuration of areas of the sample, and fibers that may be present in these areas of the specimen will be overlooked; this will lead to a low result. Undissolved filter medium also compromises the ability to obtain ED patterns. Before they are counted, TEM grids must be examined critically to determine whether they are adequately cleared of residual filter medium. It has been found that condensation washing of the grids after the initial Jaffe washer treatment, with chloroform as the solvent, clears all residual filter medium in a period of approximately 1 hour. In practice, the piece of lens tissue supporting the specimen grids is transferred to the cold finger of the condensation washer, and the washer is operated for about 1 hour. If the specimens are cleared satisfactorily by the Jaffe washer alone, the condensation washer step may be unnecessary.

8. TEM specimen preparation from MCE filters.

a. This method of preparing TEM specimens from MCE filters is similar to that specified in NIOSH Method 7402. See References 7, 8, and 9 of Unit III.L.

b. Upon receipt at the analytical laboratory, the sample cassettes must be cleaned of any contamination adhering to the outside surfaces before entering the clean sample preparation area.

c. Remove a section from any quadrant of the sample and blank filters.

d. Place the section on a clean microscope slide. Affix the filter section to the slide with a gummed paged reinforcement or other suitable means. Label the slide with a water and solvent-proof marking pen.

e. Place the slide in a petri dish which contains several paper filters soaked with 2 to 3 mL acetone. Cover the dish. Wait 2 to 4 minutes for the sample filter to fuse and clear.

f. Plasma etching of the collapsed filter is required.

i. The microscope slide to which the collapsed filter pieces are attached is placed in a plasma asher. Because plasma ashers vary greatly in their performance, both from unit to unit and between different positions in the asher chamber, it is difficult to specify the conditions that should be used. This is one area of the method that requires further evaluation. Insufficient etching will result in a failure to expose embedded filters, and too much etching may result in loss of particulate from the surface. As an interim measure, it is recommended that the time for ashing of a known weight of a collapsed filter be established and that the etching rate be calculated in terms of micrometers per second. The actual etching time used for a particular asher and operating conditions will then be set such that a 1-2 µm (10 percent) layer of collapsed surface will be removed.

ii. Place the slide containing the collapsed filters into a low-temperature plasma asher, and etch the filter.

g. Transfer the slide to a rotating stage inside the bell jar of a vacuum evaporator. Evaporate a 1 mm x 5 mm section of graphite rod onto the cleared filter. Remove the slide to a clean, dry, covered petri dish.

h. Prepare a second petri dish as a Jaffe washer with the wicking substrate prepared from filter or lens paper placed on top of a 6 mm thick disk of clean spongy polyurethane foam. Cut a V-notch on the edge of the foam and filter paper. Use the V-notch as a reservoir for adding solvent. The wicking substrate should be thin enough to fit into the petri dish without touching the lid.

i. Place carbon-coated TEM grids face up on the filter or lens paper. Label the grids by marking with a pencil on the filter paper or by putting registration marks on the petri dish lid and marking with a waterproof marker on the dish lid. In a fume hood, fill the dish with acetone until the wicking substrate is saturated. The level of acetone should be just high enough to saturate the filter paper without creating puddles.

j. Remove about a quarter section of the carbon-coated filter samples from the glass slides using a surgical knife and tweezers. Carefully place the section of the filter, carbon side down, on the appropriately labeled grid in the acetone-saturated petri dish. When all filter sections have been transferred, slowly add more solvent to the wedge-shaped trough to bring the acetone level up to the highest possible level without disturbing the sample preparations. Cover the petri dish. Elevate one side of the petri dish by placing a slide under it. This allows drops of condensed solvent vapors to form near the edge rather than in the center where they would drip onto the grid preparation.

G. TEM Method

1. *Instrumentation.*

a. Use an 80-120 kV TEM capable of performing electron diffraction with a fluorescent screen inscribed with calibrated gradations. If the TEM is equipped with EDXA it must either have a STEM attachment or be capable of producing a spot less than 250 nm in diameter at crossover. The microscope shall be calibrated routinely (see Unit III.J.) for magnification and camera constant.

b. While not required on every microscope in the laboratory, the laboratory must have either one microscope equipped with energy dispersive X-ray analysis or access to an equivalent system on a TEM in another laboratory. This must be an Energy Dispersive X-ray Detector mounted on TEM column and associated hardware/software to collect, save, and read out spectral information. Calibration of Multi-Channel Analyzer shall be checked regularly for Al at 1.48 KeV and Cu at 8.04 KeV, as well as the manufacturer's procedures.

i. Standard replica grating may be used to determine magnification (e.g., 2160 lines/mm).

ii. Gold standard may be used to determine camera constant.

c. Use a specimen holder with single tilt and/or double tilt capabilities.

2. Procedure.

a. Start a new Count Sheet for each sample to be analyzed. Record on count sheet: analyst's initials and date; lab sample number; client sample number microscope identification; magnification for analysis; number of predetermined grid openings to be analyzed; and grid identification. See the following Figure 4:

FIGURE 4--COUNT SHEET

Lab Sample No. ______________ Filter Type ______________ Operator ______________
Client Sample No. ______________ Filter Area ______________ Date ______________
Instrument I.D. ______________ Grid I.D. ______________ Comments ______________
Magnification ______________ Grid Opening (GO) Area ______________ ______________
Acc. Voltage ______________ No. GO to be Analyzed ______________ ______________

GO	Structure No.	Structure Type*	Length		ED Observation				EDAX
			< 5um	≥ 5 um	Chrys.	Amph.	Nonasb.	Neg. ID	

GO	Structure No.	Structure Type*	Length		ED Observation				EDAX
			< 5um	≥ 5 um	Chrys.	Amph.	Nonasb.	Neg. ID	

*B = Bundle
C = Cluster
F = Fiber
M = Matrix

NFD = No fibers detected
N = No diffraction obtained

b. Check that the microscope is properly aligned and calibrated according to the manufacturer's specifications and instructions

c. Microscope settings: 80-120 kV, grid assessment 250-1000X, then 15,000-20,000X screen magnification for analysis.

d. Approximately one-half (0.5) of the predetermined sample area to be analyzed shall be performed on one sample grid preparation and the remaining half on a second sample grid preparation.

e. Determine the suitability of the grid.

i. Individual grid openings with greater than 5 percent openings (holes) or covered with greater than 25 percent particulate matter or obviously having nonuniform loading shall not be analyzed.

ii. Examine the grid at low magnification (<1000X) to determine its suitability for detailed study at higher magnifications.

iii. Reject the grid if:

(1) Less than 50 percent of the grid openings covered by the replica are intact.

(2) It is doubled or folded.

(3) It is too dark because of incomplete dissolution of the filter.

iv. If the grid is rejected, load the next sample grid.

v. If the grid is acceptable, continue on to Step 6 if mapping is to be used; otherwise proceed to Step 7.

f. Grid Map (Optional).

i. Set the TEM to the low magnification mode.

ii. Use flat edge or finder grids for mapping.

iii. Index the grid openings (fields) to be counted by marking the acceptable fields for one-half (0.5) of the area needed for analysis on each of the two grids to be analyzed. These may be marked just before examining each grid opening (field), if desired.

iv. Draw in any details which will allow the grid to be properly oriented if it is reloaded into the microscope and a particular field is to be reliably identified.

g. Scan the grid.

i. Select a field to start the examination.

ii. Choose the appropriate magnification (15,000 to 20,000X screen magnification).

iii. Scan the grid as follows.

(1) At the selected magnification, make a series of parallel traverses across the field. On reaching the end of one traverse, move the image one window and reverse the traverse.

NOTE: A slight overlap should be used so as not to miss any part of the grid opening (field).

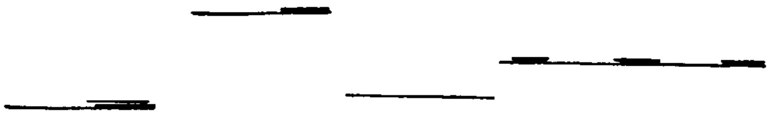
(2) Make parallel traverses until the entire grid opening (field) has been scanned.

h. Identify each structure for appearance and size.

i. Appearance and size: Any continuous grouping of particles in which an asbestos fiber within aspect ratio greater than or equal to 5:1 and a length greater than or equal to 0.5 µm is detected shall be recorded on the count sheet. These will be designated asbestos structures and will be classified as fibers, bundles, clusters, or matrices. Record as individual fibers any contiguous grouping having 0, 1, or 2 definable intersections. Groupings having more than 2 intersections are to be described as cluster or matrix. See the following Figure 5:

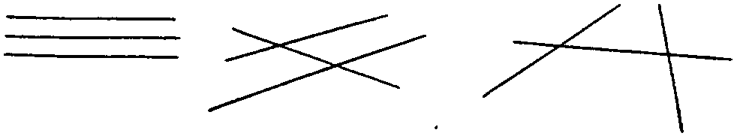
FIGURE 5--COUNTING GUIDELINES USED IN DETERMINING ASBESTOS STRUCTURES

Count as 1 fiber; 1 Structure; no intersections.



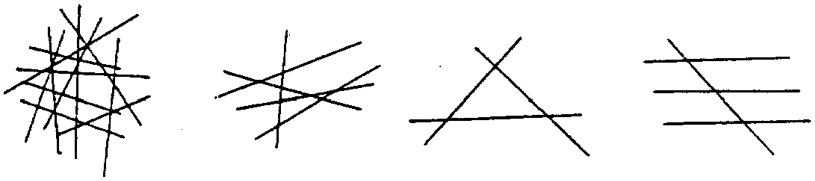
Count as 2 fibers if space between fibers is greater than width of 1 fiber diameter or number of intersections is equal to or less than 1.

Count as 3 structures if space between fibers is greater than width of 1 fiber diameter or if the number of intersections is equal to or less than 2.

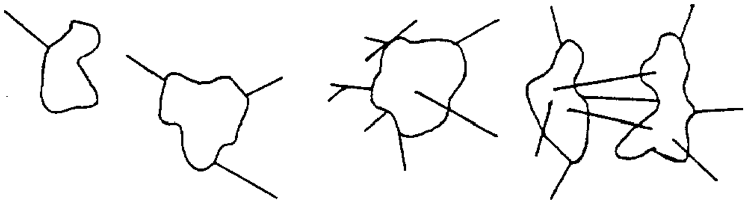


Count bundles as 1 structure; 3 or more parallel fibrils less than 1 fiber diameter separation.

Count clusters as 1 structure; fibers having greater than or equal to 3 intersections.



Count matrix as 1 structure.



DO NOT COUNT AS STRUCTURES:

Fiber protrusion
<5:1 Aspect Ratio

No fiber protusion

Fiber protrusion
<0.5 micrometer

— <0.5 micrometer in length
▬ <5:1 Aspect Ratio

An intersection is a non-parallel touching or crossing of fibers, with the projection having an aspect ratio of 5:1 or greater. Combinations such as a matrix and cluster, matrix and bundle, or bundle and cluster are categorized by the dominant fiber quality—cluster, bundle, and matrix, respectively. Separate categories will be maintained for fibers less than 5 µm and for fibers greater than or equal to 5 µm in length. Not required, but useful, may be to record the fiber length in 1 µm intervals. (Identify each structure morphologically and analyze it as it enters the "window".)

(1) *Fiber.* A structure having a minimum length greater than 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed, no intersections.

(2) *Bundle.* A structure composed of 3 or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

(3) *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group; groupings must have more than 2 intersections.

(4) *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

(5) *NSD.* Record NSD when no structures are detected in the field.

(6) *Intersection.* Non-parallel touching or crossing of fibers, with the projection having an aspect ratio 5:1 or greater.

ii. Structure Measurement.

(1) Recognize the structure that is to be sized.

(2) Memorize its location in the "window" relative to the sides, inscribed square and to other particulates in the field so this exact location can be found again when scanning is resumed.

(3) Measure the structure using the scale on the screen.

(4) Record the length category and structure type classification on the count sheet after the field number and fiber number.

(5) Return the fiber to its original location in the window and scan the rest of the field for other fibers; if the direction of travel is not remembered, return to the right side of the field and begin the traverse again.

i. Visual identification of Electron Diffraction (ED) patterns is required for each asbestos structure counted which would cause the analysis to exceed the 70 s/mm^2 concentration. (Generally this means the first four fibers identified as asbestos must exhibit an identifiable diffraction pattern for chrysotile or amphibole.)

i. Center the structure, focus, and obtain an ED pattern. (See Microscope Instruction Manual for more detailed instructions.)

ii. From a visual examination of the ED pattern, obtained with a short camera length, classify the observed structure as belonging to one of the following classifications: chrysotile, amphibole, or nonasbestos.

(1) Chrysotile: The chrysotile asbestos pattern has characteristic streaks on the layer lines other than the central line and some streaking also on the central line. There will be spots of normal sharpness on the central layer line and on alternate lines (2nd, 4th, etc.). The repeat distance between layer lines is 0.53 nm and the center doublet is at 0.73 nm. The pattern should display (002), (110), (130) diffraction maxima; distances and geometry should match a chrysotile pattern and be measured semiquantitatively.

(2) Amphibole Group [includes grunerite (amosite), crocidolite, anthophyllite, tremolite, and actinolite]: Amphibole asbestos fiber patterns show layer lines formed by very closely spaced dots, and the repeat distance between layer lines is also about 0.53 nm. Streaking in layer lines is occasionally present due to crystal structure defects.

(3) Nonasbestos: Incomplete or unobtainable ED patterns, a nonasbestos EDXA, or a nonasbestos morphology.

iii. The micrograph number of the recorded diffraction patterns must be reported to the client and maintained in the laboratory's quality assurance records. The records must also demonstrate that the identification of the pattern has been verified by a qualified individual and that the operator who made the identification is maintaining at least an 80 percent correct visual identification based on his measured patterns. In the event that examination of the pattern by the qualified individual indicates that the pattern had been misidentified visually, the client shall be contacted. If the pattern is a suspected chrysotile, take a photograph of the diffraction pattern at 0 degrees tilt. If the structure is suspected to be amphibole, the sample may have to be tilted to obtain a simple geometric array of spots.

j. Energy Dispersive X-Ray Analysis (EDXA).

i. Required of all amphiboles which would cause the analysis results to exceed the 70 s/mm^2 concentration. (Generally speaking, the first 4 amphiboles would require EDXA.)

ii. Can be used alone to confirm chrysotile after the 70 s/mm^2 concentration has been exceeded.

iii. Can be used alone to confirm all nonasbestos.

iv. Compare spectrum profiles with profiles obtained from asbestos standards. The closest match identifies and categorizes the structure.

v. If the EDXA is used for confirmation, record the properly labeled spectrum on a computer disk, or if a hard copy, file with analysis data.

vi. If the number of fibers in the nonasbestos class would cause the analysis to exceed the 70 s/mm^2 concentration, their identities must be confirmed by EDXA or measurement of a zone axis diffraction pattern to establish that the particles are nonasbestos.

k. Stopping Rules.

i. If more than 50 asbestiform structures are counted in a particular grid opening, the analysis may be terminated.

ii. After having counted 50 asbestiform structures in a minimum of 4 grid openings, the analysis may be terminated. The grid opening in which the 50th fiber was counted must be completed.

iii. For blank samples, the analysis is always continued until 10 grid openings have been analyzed.

iv. In all other samples the analysis shall be continued until an analytical sensitivity of 0.005 s/cm^3 is reached.

l. Recording Rules. The count sheet should contain the following information:

i. Field (grid opening): List field number.

ii. Record "NSD" if no structures are detected.

iii. Structure information.

(1) If fibers, bundles, clusters, and/or matrices are found, list them in consecutive numerical order, starting over with each field.

(2) Length. Record length category of asbestos fibers examined. Indicate if less than 5 µm or greater than or equal to 5 µm.

(3) Structure Type. Positive identification of asbestos fibers is required by the method. At least one diffraction pattern of each fiber type from every five samples must be recorded and compared with a standard diffraction pattern. For each asbestos fiber reported, both a morphological descriptor and an identification descriptor shall be specified on the count sheet.

(4) Fibers classified as chrysotile must be identified by diffraction and/or X-ray analysis and recorded on the count sheet. X-ray analysis alone can be used as sole identification only after 70s/mm^2 have been exceeded for a particular sample.

(5) Fibers classified as amphiboles must be identified by X-ray analysis and electron diffraction and recorded on the count sheet. (X-ray analysis alone can be used as sole identification only after 70s/mm^2 have been exceeded for a particular sample.)

(6) If a diffraction pattern was recorded on film, the micrograph number must be indicated on the count sheet.

(7) If an electron diffraction was attempted and an appropriate spectra is not observed, N should be recorded on the count sheet.

(8) If an X-ray analysis is attempted but not observed, N should be recorded on the count sheet.

(9) If an X-ray analysis spectrum is stored, the file and disk number must be recorded on the count sheet.

m. Classification Rules.

i. *Fiber.* A structure having a minimum length greater than or equal to 0.5 µm and an aspect ratio (length to width) of 5:1 or greater and substantially parallel sides. Note the appearance of the end of the fiber, i.e., whether it is flat, rounded or dovetailed.

ii. *Bundle.* A structure composed of three or more fibers in a parallel arrangement with each fiber closer than one fiber diameter.

iii. *Cluster.* A structure with fibers in a random arrangement such that all fibers are intermixed and no single fiber is isolated from the group. Groupings must have more than two intersections.

iv. *Matrix.* Fiber or fibers with one end free and the other end embedded in or hidden by a particulate. The exposed fiber must meet the fiber definition.

v. *NSD.* Record NSD when no structures are detected in the field.

n. After all necessary analyses of a particle structure have been completed, return the goniometer stage to 0 degrees, and return the structure to its original location by recall of the original location.

o. Continue scanning until all the structures are identified, classified and sized in the field.

p. Select additional fields (grid openings) at low magnification; scan at a chosen magnification (15,000 to 20,000X screen magnification); and analyze until the stopping rule becomes applicable.

q. Carefully record all data as they are being collected, and check for accuracy.

r. After finishing with a grid, remove it from the microscope, and replace it in the appropriate grid hold. Sample grids must be stored for a minimum of 1 year from the date of the analysis; the sample cassette must be retained for a minimum of 30 days by the laboratory or returned at the client's request.

H. Sample Analytical Sequence

1. Carry out visual inspection of work site prior to air monitoring.

2. Collect a minimum of five air samples inside the work site and five samples outside the work site. The indoor and outdoor samples shall be taken during the same time period.

3. Analyze the abatement area samples according to this protocol. The analysis must meet the 0.005 s/cm^3 analytical sensitivity.

4. Remaining steps in the analytical sequence are contained in Unit IV. of this Appendix.

I. Reporting

The following information must be reported to the client. See the following Table II:

TABLE II--EXAMPLE LABORATORY LETTERHEAD

Laboratory I.D.	Client I.D.	FILTER MEDIA DATA				Analyzed Area, mm^2	Sample Volume, cc
		Type	Diameter, mm	Effective Area, mm^2	Pore Size, µm		

INDIVIDUAL ANALYTICAL RESULTS

Laboratory I.D.	Client I.D.	# Asbestos Structures	Analytical Sensitivity, s/cc	CONCENTRATION	
				Structures/mm^2	Structures/cc

The analysis was carried out to the approved TEM method. This laboratory is in compliance with the quality specified by the method.

____
Authorized Signature

1. Concentration in structures per square millimeter and structures per cubic centimeter.
2. Analytical sensitivity used for the analysis.
3. Number of asbestos structures.
4. Area analyzed.
5. Volume of air samples (which was initially provided by client).
6. Average grid size opening.
7. Number of grids analyzed.
8. Copy of the count sheet must be included with the report.

9. Signature of laboratory official to indicate that the laboratory met specifications of the AHERA method.

10. Report form must contain official laboratory identification (e.g., letterhead).

11. Type of asbestos.

J. Calibration Methodology

NOTE: Appropriate implementation of the method requires a person knowledgeable in electron diffraction and mineral identification by ED and EDXA. Those inexperienced laboratories wishing to develop capabilities may acquire necessary knowledge through analysis of appropriate standards and by following detailed methods as described in References 8 and 10 of Unit III.L.

1. *Equipment Calibration.* In this method, calibration is required for the air-sampling equipment and the transmission electron microscope (TEM).

a. *TEM Magnification.* The magnification at the fluorescent screen of the TEM must be calibrated at the grid opening magnification (if used) and also at the magnification used for fiber counting. This is performed with a cross grating replica. A logbook must be maintained, and the dates of calibration depend on the past history of the particular microscope; no frequency is specified. After any maintenance of the microscope that involved adjustment of the power supplied to the lenses or the high-voltage system or the mechanical disassembly of the electron optical column apart from filament exchange, the magnification must be recalibrated. Before the TEM calibration is performed, the analyst must ensure that the cross grating replica is placed at the same distance from the objective lens as the specimens are. For instruments that incorporate an eucentric tilting specimen stage, all speciments and the cross grating replica must be placed at the eucentric position.

b. Determination of the TEM magnification on the fluorescent screen.

i. Define a field of view on the fluorescent screen either by markings or physical boundaries. The field of view must be measurable or previously inscribed with a scale or concentric circles (all scales should be metric).

ii. Insert a diffraction grating replica (for example a grating containing 2,160 lines/mm) into the specimen holder and place into the microscope. Orient the replica so that the grating lines fall perpendicular to the scale on the TEM fluorescent screen. Ensure that the goniometer stage tilt is 0 degrees.

iii. Adjust microscope magnification to 10,000X or 20,000X. Measure the distance (mm) between two widely separated lines on the grating replica. Note the number of spaces between the lines. Take care to measure between the same relative positions on the lines (e.g., between left edges of lines).

NOTE: The more spaces included in the measurement, the more accurate the final calculation. On most microscopes, however, the magnification is substantially constant only within the central 8-10 cm diameter region of the fluorescent screen.

iv. Calculate the true magnification (M) on the fluorescent screen:

$$M=XG/Y$$

where:

X=total distance (mm) between the designated grating lines;

G=calibration constant of the grating replica (lines/mm):

Y=number of grating replica spaces counted along X.

c. Calibration of the EDXA System. Initially, the EDXA system must be calibrated by using two reference elements to calibrate the energy scale of the instrument. When this has been completed in accordance with the manufacturer's instructions, calibration in terms of the different types of asbestos can proceed. The EDXA detectors vary in both solid angle of detection and in window thickness. Therefore, at a particular accelerating voltage in use on the TEM, the count rate obtained from specific dimensions of fiber will vary both in absolute X-ray count rate and in the relative X-ray peak heights for different elements. Only a few minerals are relevant for asbestos abatement work, and in this procedure the calibration is specified in terms of a "fingerprint" technique. The EDXA spectra must be recorded from individual fibers of the relevant minerals, and identifications are made on the basis of semiquantitative comparisons with these reference spectra.

d. Calibration of Grid Openings.

i. Measure 20 grid openings on each of 20 random 200-mesh copper grids by placing a grid on a glass slide and examining it under the PCM. Use a calibrated graticule to measure the average field diameter and use this number to calculate the field area for an average grid opening. Grids are to be randomly selected from batches up to 1,000.

NOTE: A grid opening is considered as one field.

ii. The mean grid opening area must be measured for the type of specimen grids in use. This can be accomplished on the TEM at a properly calibrated low magnification or on an optical microscope at a magnification of approximately 400X by using an eyepiece fitted with a scale that has been calibrated against a stage micrometer. Optical microscopy utilizing manual or automated procedures may be used providing instrument calibration can be verified.

e. Determination of Camera Constant and ED Pattern Analysis.

i. The camera length of the TEM in ED operating mode must be calibrated before ED patterns on unknown samples are observed. This can be achieved by using a carbon-coated grid on which a thin film of gold has been sputtered or evaporated. A thin film of gold is evaporated on the specimen TEM grid to obtain zone-axis ED patterns superimposed with a ring pattern from the polycrystalline gold film.

ii. In practice, it is desirable to optimize the thickness of the gold film so that only one or two sharp rings are obtained on the superimposed ED pattern. Thicker gold film would normally give multiple gold rings, but it will tend to mask weaker diffraction spots from the unknown fibrous particulates. Since the unknown d-spacings of most interest in asbestos analysis are those which lie closest to the transmitted beam, multiple gold rings are unnecessary on zone-axis ED patterns. An average camera constant using multiple gold rings can be determined. The camera constant is one-half the diameter, D, of the rings times the interplanar spacing, d, of the ring being measured.

K. Quality Control/Quality Assurance Procedures (Data Quality Indicators)

Monitoring the environment for airborne asbestos requires the use of sensitive sampling and analysis procedures. Because the test is sensitive, it may be influenced by a variety of factors. These include the supplies used in the sampling operation, the performance of the sampling, the preparation of the grid from the filter and the actual examination of this grid in the microscope. Each of these unit operations must produce a product of defined quality if the analytical result is to be a reliable and meaningful test result. Accordingly, a series of control checks and reference standards is performed along with the sample analysis as indicators that the materials used are adequate and the operations are within acceptable limits. In this way, the quality of the data is defined and the results are of known value. These checks and tests also provide timely and specific warning of any problems which might develop within the sampling and analysis operations. A description of these quality control/quality assurance procedures is summarized in the following Table III:

TABLE III--SUMMARY OF LABORATORY
DATA QUALITY OBJECTIVES

Unit Operation	QC Check	Frequency	Conformance Expectation
Sample receiving	Review of receiving report	Each sample	95% complete
Sample custody	Review of chain-of-custody record	Each sample	95% complete
Sample preparation	Supplies and reagents	On receipt	Meet specs. or reject
	Grid opening size	20 openings/20 grids/lot of 1000 or 1 opening/sample	100%
	Special clean area monitoring	After cleaning or service	Meet specs or reclean
	Laboratory blank	1 per prep series or 10%	Meet specs. or reanalyze series
	Plasma etch blank	1 per 20 samples	75%
	Multiple preps (3 per sample)	Each sample	One with cover of 15 complete grid sqs.
Sample analysis	System check	Each day	Each day
	Alignment check	Each day	Each day
	Magnification calibration with low and high standards	Each month or after service	95%
	ED calibration by gold standard	Weekly	95%
	EDS calibration by copper line	Daily	95%
Performance check	Laboratory blank (measure of cleanliness)	Prep 1 per series or 10% read 1 per 25 samples	Meet specs or reanalyze series
	Replicate counting (measure of precision)	1 per 100 samples	1.5 x Poisson Std. Dev
	Duplicate analysis (measure of reproducibility)	1 per 100 samples	2 x Poisson Std. Dev.
	Known samples of typical materials (working standards)	Training and for comparison with unknowns	100%
	Analysis of NBS SRM 1876 and/or RM 8410 (measure of accuracy and comparability)	1 per analyst per year	1.5 x Poisson Std. Dev
	Data entry review (data validation and measure of completeness)	Each sample	95%
	Record and verify ID electron diffraction pattern of structure	1 per 5 samples	80% accuracy
Calculations and data reduction	Hand calculation of automated data reduction procedure or independent recalculation of hand-calculated data	1 per 100 samples	85%

1. When the samples arrive at the laboratory, check the samples and documentation for completeness and requirements before initiating the analysis.

2. Check all laboratory reagents and supplies for acceptable asbestos background levels.

3. Conduct all sample preparation in a clean room environment monitored by laboratory blanks and special testing after cleaning or servicing the room.

4. Prepare multiple grids of each sample.

5. Provide laboratory blanks with each sample batch. Maintain a cumulative average of these results. If this average is greater than 53 f/mm^2 per 10 200-mesh grid openings, check the system for possible sources of contamination.

6. Check for recovery of asbestos from cellulose ester filters submitted to plasma asher.

7. Check for asbestos carryover in the plasma asher by including a blank alongside the positive control sample

8. Perform a systems check on the transmission electron microscope daily.

9. Make periodic performance checks of magnification, electron diffraction and energy dispersive X-ray systems as set forth in Table III of Unit III.K.

10. Ensure qualified operator performance by evaluation of replicate counting, duplicate analysis, and standard sample comparisons as set forth in Table III of Unit III.K.

11. Validate all data entries.

12. Recalculate a percentage of all computations and automatic data reduction steps as specified in Table III.

13. Record an electron diffraction pattern of one asbestos structure from every five samples that contain asbestos. Verify the identification of the pattern by measurement or comparison of the pattern with patterns collected from standards under the same conditions.

The outline of quality control procedures presented above is viewed as the minimum required to assure that quality data is produced for clearance testing of an asbestos abated area. Additional information may be gained by other control tests. Specifics on those control procedures and options available for environmental testing can be obtained by consulting References 6, 7, and 11 of Unit III.L.

L. References

For additional background information on this method the following references should be consulted.

1. "Guidelines for Controlling Asbestos-Containing Materials in Buildings," EPA 560/5-85-024, June 1985.

2. "Measuring Airborne Asbestos Following an Abatement Action," USEP/Office of Pollution Prevention and Toxics, EPA 600/4-85-049, 1985.

3. Small, John and E. Steel. Asbestos Standards: Materials and Analytical Methods. N.B.S. Special Publication 619, 1982.

4. Campbell, W.J., R.L. Blake, L.L. Brown, E.E. Cather, and J.J. Sjoberg. Selected Silicate Minerals and Their Asbestiform Varieties. Information Circular 8751, U.S. Bureau of Mines, 1977.

5. Quality Assurance Handbook for Air Pollution Measurement System. Ambient Air Methods, EPA 600/4-77-027a, USEPA, Office of Research and Development, 1977.

6. Method 2A: Direct Measurement of Gas Volume Through Pipes and Small Ducts. 40 CFR Part 60 Appendix A.

7. Burdette, G.J. Health & Safety Exec., Research & Lab. Services Div., London, "Proposed Analytical Method for Determination of Asbestos in Air."

8. Chatfield, E.J., Chatfield Tech. Cons., Ltd., Clark, T., PEI Assoc. "Standard Operating Procedure for Determination of Airborne Asbestos Fibers by Transmission Electron Microscopy Using Polycarbonate Membrane Filters." WERL SOP 87-1, March 5, 1987.

9. NIOSH. Method 7402 for Asbestos Fibers, December 11, 1986 Draft.

10. Yamate, G., S.C. Agarwall, R.D. Gibbons, IIT Research Institute, "Methodology for the Measurement of Airborne Asbestos by Electron Microscopy." Draft report, USEPA Contract 68-02-3266, July 1984.

11. Guidance to the Preparation of Quality Assurance Project Plans, USEPA, Office of Pollution Prevention and Toxics, 1984.

IV. Mandatory Interpretation of Transmission Electron Microscopy Results to Determine Completion of Response Actions

A. Introduction

A response action is determined to be completed by TEM when the abatement area has been cleaned and the airborne asbestos concentration inside the abatement area is no higher than concentrations at locations outside the abatement area. "Outside" means outside the abatement area, but not necessarily outside the building. EPA reasons that an asbestos removal contractor cannot be expected to clean an abatement area to an airborne asbestos concentration that is lower than the concentration of air entering the abatement area from outdoors or from other parts of the building. After the abatement area has passed a thorough visual inspection, and before the outer containment barrier is removed, a minimum of five air samples inside the abatement area and a minimum of five air samples outside the abatement area must be collected. Hence, the response action is determined to be completed when the average airborne asbestos concentration measured inside the abatement area is not statistically different from the average airborne asbestos concentration measured outside the abatement area.

The inside and outside concentrations are compared by the Z-test, a statistical test that takes into account the variability in the measurement process. A minimum of five samples inside the abatement area and five samples outside the abatement area are required to control the false negative error rate, i.e., the probability of declaring the removal complete when, in fact, the air concentration inside the abatement area is significantly higher than outside the abatement area. Additional quality control is provided by requiring three blanks (filters through which no air has been drawn) to be analyzed to check for unusually high filter contamination that would distort the test results.

When volumes greater than or equal to 1,199 L for a 25 mm filter and 2,799 L for a 37 mm filter have been collected and the average number of asbestos structures on samples inside the abatement area is no greater than 70 s/mm^2 of filter, the response action may be considered complete without comparing the inside samples to the outside samples. EPA is permitting this initial screening test to save analysis costs in situations where the airborne asbestos concentration is sufficiently low so that it cannot be distinguished from the filter contamination/background level (fibers deposited on the filter that are unrelated to the air being sampled). The screening test cannot be used when volumes of less than 1,199 L for 25 mm filter or 2,799 L for a 37 mm filter are collected because the ability to distinguish levels significantly different from filter background is reduced at low volumes.

The initial screening test is expressed in structures per square millimeter of filter because filter background levels come from sources other than the air being sampled and cannot be meaningfully expressed as a concentration per cubic centimeter of air. The value of 70 s/mm² is based on the experience of the panel of microscopists who consider one structure in 10 grid openings (each grid opening with an area of 0.0057 mm²) to be comparable with contamination/background levels of blank filters. The decision is based, in part, on Poisson statistics which indicate that four structures must be counted on a filter before the fiber count is statistically distinguishable from the count for one structure. As more information on the performance of the method is collected, this criterion may be modified. Since different combinations of the number and size of grid openings are permitted under the TEM protocol, the criterion is expressed in structures per square millimeter of filter to be consistent across all combinations. Four structures per 10 grid openings corresponds to approximately 70 s/mm².

B. Sample Collection and Analysis

1. A minimum of 13 samples is required: five samples collected inside the abatement area, five samples collected outside the abatement area, two field blanks, and one sealed blank.

2. Sampling and TEM analysis must be done according to either the mandatory or nonmandatory protocols in Appendix A. At least 0.057 mm² of filter must be examined on blank filters.

C. Interpretation of Results

1. The response action shall be considered complete if either:

a. Each sample collected inside the abatement area consists of at least 1,199 L of air for a 25 mm filter, or 2,799 L of air for a 37 mm filter, and the arithmetic mean of their asbestos structure concentrations per square millimeter of filter is less than or equal to 70 s/mm²; or

b. The three blank samples have an arithmetic mean of the asbestos structure concentration on the blank filters that is less than or equal to 70 s/mm² and the average airborne asbestos concentration measured inside the abatement area is not statistically higher than the average airborne asbestos concentration measured outside the abatement area as determined by the Z-test. The Z-test is carried out by calculating

$$Z = \frac{\bar{Y}_I - \bar{Y}_O}{0.8(1/n_I + 1/n_O)^{1/2}}$$

where Y_I is the average of the natural logarithms of the inside samples and Y_O is the average of the natural logarithms of the outside samples, n_I is the number of inside samples and n_O is the number of outside samples. The response action is considered complete if Z is less than or equal to 1.65.

NOTE: When no fibers are counted, the calculated detection limit for that analysis is inserted for the concentration.

2. If the abatement site does not satisfy either (1) or (2) of this Section C, the site must be recleaned and a new set of samples collected.

D. Sequence for Analyzing Samples

It is possible to determine completion of the response action without analyzing all samples. Also, at any point in the process, a decision may be made to terminate the analysis of existing samples, reclean the abatement site, and collect a new set of samples. The following sequence is outlined to minimize the number of analyses needed to reach a decision.

1. Analyze the inside samples.

2. If at least 1,199 L of air for a 25 mm filter or 2,799 L of air for a 37 mm filter is collected for each inside sample and the arithmetic mean concentration of structures per square millimeter of filter is less than or equal to 70 s/mm², the response action is complete and no further analysis is needed.

3. If less than 1,199 L of air for a 25 mm filter or 2,799 L of air for a 37 mm filter is collected for any of the inside samples, or the arithmetic mean concentration of structures per square millimeter of filter is greater than 70 s/mm², analyze the three blanks.

4. If the arithmetic mean concentration of structures per square millimeter on the blank filters is greater than 70 s/mm², terminate the analysis, identify and correct the source of blank contamination, and collect a new set of samples.

5. If the arithmetic mean concentration of structures per square millimeter on the blank filters is less than or equal to 70 s/mm², analyze the outside samples and perform the Z-test.

6. If the Z-statistic is less than or equal to 1.65, the response action is complete. If the Z-statistic is greater than 1.65, reclean the abatement site and collect a new set of samples.

[52 FR 41857, Oct. 30, 1987]

APPENDIX B TO SUBPART E—WORK PRACTICES AND ENGINEERING CONTROLS FOR SMALL-SCALE, SHORT-DURATION OPERATIONS MAINTENANCE, AND REPAIR (O&M) ACTIVITIES INVOLVING ACM

This appendix is not mandatory, in that LEAs may choose to comply with all the requirements of 40 CFR 763.121. Section 763.91(b) extends the protection provided by EPA in its 40 CFR 763.121 for worker protection during asbestos abatement projects to employees of local education agencies who perform small-scale, short-duration operations, maintenance and repair (O&M) activities involving asbestos-containing materials and are not covered by the OSHA asbestos construction standard at 29 CFR 1926.58 or an asbestos worker protection standard adopted by a State as part of a State plan approved by OSHA under section 18 of the Occupational Safety and Health Act. Employers wishing to be exempt from the requirements of §763.121 (e)(6) and (f)(2)(i) may instead comply with the provisions of this appendix when performing small-scale, short-duration O&M activities.

Definition of Small-Scale, Short-Duration Activities

For the purposes of this appendix, small-scale, short-duration maintenance activities are tasks such as, but not limited to:

1. Removal of asbestos-containing insulation on pipes.
2. Removal of small quantities of asbestos-containing insulation on beams or above ceilings.
3. Replacement of an asbestos-containing gasket on a valve.
4. Installation or removal of a small section of drywall.
5. Installation of electrical conduits through or proximate to asbestos-containing materials.

Small-scale, short-duration maintenance activities can be further defined, for the purposes of this subpart, by the following considerations:

1. Removal of small quantities of asbestos-containing materials (ACM) only if required in the performance of another maintenance activity not intended as asbestos abatement.
2. Removal of asbestos-containing thermal system insulation not to exceed amounts greater than those which can be contained in a single glove bag.
3. Minor repairs to damaged thermal system insulation which do not require removal.
4. Repairs to a piece of asbestos-containing wallboard.
5. Repairs, involving encapsulation, enclosure or removal, to small amounts of friable asbestos-containing material only if required in the performance of emergency or routine maintenance activity and not intended solely as asbestos abatement. Such work may not exceed amounts greater than those which can be contained in a single prefabricated minienclosure. Such an enclosure shall conform spatially and geometrically to the localized work area, in order to perform its intended containment function.

OSHA concluded that the use of certain engineering and work practice controls is capable of reducing employee exposures to asbestos to levels below the final standard's action level (0.1 f/cm^3). (See 51 FR 22714, June 20, 1986.) Several controls and work practices, used either singly or in combination, can be employed effectively to reduce asbestos exposures during small maintenance and renovation operations. These include:

1. Wet methods.
2. Removal methods.
   i. Use of glove bags.
   ii. Removal of entire asbestos insulated pipes or structures.
   iii. Use of minienclosures.
3. Enclosure of asbestos materials.
4. Maintenance programs.

This appendix describes these controls and work practices in detail.

Preparation of the Area Before Renovation or Maintenance Activities

The first step in preparing to perform a small-scale, short-duration asbestos renovation or maintenance task, regardless of the abatement method that will be used, is the removal from the work area of all objects that are movable to protect them from asbestos contamination. Objects that cannot be removed must be covered completely with 6-mil-thick polyethylene plastic sheeting before the task begins. If objects have already been contaminated, they should be thoroughly cleaned with a High Efficiency Particulate Air (HEPA) filtered vacuum or be wet-wiped before they are removed from the work area or completely encased in the plastic.

Wet methods. Whenever feasible, and regardless of the abatement method to be used (e.g., removal, enclosure, use of glove bags), wet methods must be used during small-scale, short-duration maintenance and renovation activities that involve disturbing asbestos-containing materials. Handling asbestos materials wet is one of the most reliable methods of ensuring that asbestos fibers do not become airborne, and this practice should therefore be used whenever feasible.

California Environmental Protection Agency

Air Resources Board

Method 435

Determination of Asbestos Content of Serpentine Aggregate

Adopted: June 6, 1991

Method 435

Determination of Asbestos Content of Serpentine Aggregate

1 PRINCIPLE AND APPLICABILITY

1.1 Principle.

Asbestos fibers may be released from serpentine rock formations and are determined by microscopic techniques. The results are very sensitive to sampling procedures. The analytical results are reported in percent asbestos fibers which is the percent number of asbestos fibers contained in 400 randomly chosen particles of a bulk sample. Since the homogeneity of the material is unknown, the uncertainty in the sampling cannot be defined. The uncertainty of the analytical technique is two percent if twenty asbestos fibers are counted in a sample of 400 particles. The derivation of this uncertainty value is explained in Section 7.4.

1.2 Applicability.

This method is applicable to determining asbestos content of serpentine aggregate in storage piles, on conveyor belts, and on surfaces such as roads, shoulders, and parking lots.

2 DEFINITIONS

2.1 Bulk Sample

A sample of bulk material.

2.2 Grab Sample

A sample taken from a volume of material.

2.3 Composite Sample

A mixture or blend of material from more than one grab sample.

2.4 Serpentine

Serpentinite, serpentine rock or serpentine material.

2.5 Executive Officer

The term Executive Officer as used in this method shall mean the Executive Officer of the Air Resources Board (ARB) or Air Pollution Control Officer/Executive Officer of a local air pollution control district/air quality management district.

3 APPLICABLE SOURCES

This method can be used to obtain bulk material samples from three types of sources:

1. Serpentine aggregate storage piles,

2. Serpentine aggregate conveyor belts

3. Serpentine aggregate covered surfaces.

4 SAMPLING APPARATUS

4.1 Serpentine Aggregate Storage Piles.

Tube insertion often provides the simplest method of aggregate material investigation and sampling. Insertion tubes shall be adequate to provide a relatively rapid continuous penetration force.

4.1.1 Thin-walled tubes should be manufactured as shown in Figure 1. The tube should have an outside diameter between 2 to 5 inches and be made of metal or plastic having adequate strength for penetration into aggregate piles. These tubes shall be clean and free of surface irregularities including projecting weld seams. Further information on these tubes can be found in Table 1 and ASTM D 1587-83, which is incorporated herein by reference.

4.1.2 The insertion tube can be made out of commercially available two inch PVC Schedule 40 pipe. Further information on the tube can be found in Table 2.

4.1.3 A round point shovel may be used.

4.2 Serpentine Aggregate Conveyor Belts.

4.2.1 Sampling of aggregate off a conveyor belt requires a hand trowel, a small brush, and a dust pan.

4.2.2 Two templates as shown in Figure 2 are needed to isolate material on the conveyor belt.

4.2.3 An automated belt sampler may be used.

4.3 Serpentine Aggregate Covered Surfaces.

A shovel, a hand or machine-operated auger or other suitable equipment can be used to collect samples of aggregate materials on covered surfaces.

4.3.1 Hand-Operated Augers.

4.3.1.1 Helical Augers-Small lightweight augers such as spiral-type augers and ship-type augers may be used. A description of these augers can be found in ASTM D1452-80, which is incorporated herein by reference.

4.3.1.2 Orchard barrel and open spiral-type tubular augers may be used to collect samples. These augers range in size from 1.5 through 8 inches, and have the common characteristic of appearing essentially tubular when viewed from the digging end. Further description of these auger types can be found in ASTM D1452-80.

4.3.1.3 Clam Shell or Iwan-Type post-hole augers may be used to collect samples from surfaces generally 2 through 8 inches in diameter and have a common mean of blocking the escape of soil from the auger. Further description of these augers can be found in ASTM D1452-80.

4.3.2 Machine-Operated Augers

Machine-Operated Augers such as helical augers and stinger augers may be used. These augers are normally operated by heavy-duty, high-torque machines, designed for heavy construction work. Further description of these augers can be found in ASTM D1452-80.

4.3.3 A round point shovel can also be used to obtain a sample of aggregate covered surface material.

5 SAMPLING

The sampling procedure has been developed to provide an unbiased collection of bulk samples. A sampling plan, including a description of how the grab samples will be randomly collected and the number of samples to be collected, shall be developed. Prior to conducting any sampling the sampling plan shall be submitted to the Executive Officer for approval, if the sampling is conducted for determining compliance with a rule or regulation. The amount of composite 200 mesh material, as described below, shall be sufficient to provide sample to the source or Executive Officer, if requested, and a sample to be archived for future use.

A single test as described below shall cover:

a) 1000 tons of aggregate for piles and conveyor belts, or
b) one acre aggregate covered surface, or
c) one mile of aggregate covered road, or

d) two acres or two miles of dual aggregate covered shoulders.

Exposure to airborne asbestos fibers is a health hazard. Asbestos has been listed by the Governor as causing cancer and identified by the Air Resources Board as a toxic air contaminant. Serpentine aggregate may contain asbestos. Bulk samples collected can contain friable asbestos fibers and may release fibers during sampling, handling or crushing steps. Adequate safety precautions should be followed to minimize the inhalation of asbestos fibers. Crushing should be carried out in a ventilated hood with continuous airflow (negative pressure) exhausting through an HEPA filter. Handling of samples without these precautions may result in the inhalation of airborne asbestos fibers.

5.1 Serpentine Aggregate Storage Piles.

Serpentine aggregate storage piles typically have a conical or a triangular prism shape. The aggregate is introduced at the top of the pile and is allowed to flow over the side. This action, called sloughing, causes a size segregation to occur with the finer material deposited towards the top of the pile.

The locations where grab samples will be taken are randomly chosen over the surface of the pile. The method of randomly choosing the sampling locations is left up to sampling personnel but must follow the procedures specified in the sampling personnel plan. For 1000 tons of product, a grab sample shall be taken at a minimum of three randomly chosen sampling locations. A minimum of three grab samples shall be taken even if the product pile contains less than 1000 tons of material. The slough is raked or shoveled away from the sampling location. A sampling apparatus is inserted one foot into the pile and the material is removed and is placed in an appropriate sized sampling container. Some of the possible sampling apparatus is discussed in Section 4.1. Each of the grab samples shall be placed in the same sample container. This composited sample shall be crushed to produce a material with a nominal size of less than three-eighths of an inch. Before crushing, the sample must be adequately dried. ASTM Method C-702-80, which is incorporated herein by reference, shall be used to reduce the size of the crushed grab sample to a one pint aliquot. The one pint aliquot shall be further crushed using a Braun mill or equivalent to produce a material of which the majority shall be less than 200 Tyler mesh. An aliquot of the 200 mesh material shall be put into a labeled sealed container. The label shall contain all the information described in Section 6 (except item 4).

5.2 Serpentine Aggregate Conveyor Belts.

Serpentine aggregate is transported from the rock crushing plant to a product stacking belt and finally to a storage pile or to a waiting truck for delivery to a buyer.

The grab samples shall be taken from the product stacking belt or if this is not possible then at the first transfer point before the stockpile. The grab samples shall be collected by stopping the belt a minimum of three times or using an automated sampler. The method of randomly choosing the sampling locations and intervals is left up to sampling personnel but must follow the procedure specified in the sampling plan. For 1000 tons of product, a grab sample is taken at a minimum of three randomly selected intervals. A minimum of three samples shall be taken even if the generated product is less than 1000 tons. Each time the belt is stopped to take a grab sample, templates, as shown in Figure 2, are placed a minimum of six inches apart to isolate the material on the belt. The material within the templates is removed with a small shovel or with a brush and a dust pan for the finer material and is placed in an appropriate sized sampling container. This composited sample shall be crushed to produce a material with a nominal size of less than three-eighths of an inch. Before crushing, the sample must be adequately dried. ASTM Method C-702-80, which is incorporated herein by reference, shall be used to reduce the size of the crushed grab sample to a one pint aliquot. The one pint aliquot shall be further crushed using a Bruan mill or equivalent to produce a material which the majority of which shall be less than 200 Tyler mesh. An aliquot of the 200 mesh material shall be put into a labeled sealed container. The label must contain all the information listed in Section 6 (except item 4).

5.3 Serpentine Aggregate Covered Surfaces.

5.3.1 Serpentine Aggregate Covered Roads

A serpentine aggregate-covered road shall be characterized by taking grab samples from a minimum of three randomly chosen locations per mile of road. The method of randomly choosing the sampling locations is left up to sampling personnel but must follow the procedures specified in the sampling plan. A minimum of three samples shall be taken even if the road is less than one mile long. Section 4.3 describes some of the possible sampling apparatus used to collect the grab samples. Grab samples shall not contain underlying soils. Each of the grab samples shall be placed in the same sample container. This composited sample shall be crushed to produce a material with a nominal size of less than three-eighths of an inch. Before crushing, the sample must be adequately dried. ASTM Method C-702-80, which is incorporated herein by reference, shall be used to reduce the size of the crushed grab sample to a one pint aliquot. The one pint aliquot shall be further crushed using a Bruan mill or equivalent to produce a material which the majority of which shall be less than 200 Tyler mesh. An aliquot of the 200 mesh material shall be put into a labeled sealed container. The label must contain all the information listed in Section 6 (except item 4).

5.3.2 Serpentine Aggregate Covered Areas

A serpentine aggregate-covered play yard or parking lot shall be characterized by taking grab samples from a minimum of three randomly chosen locations per acre. The method of randomly choosing the sampling locations is left up to sampling personnel but must follow the procedures specified in the sampling plan. A minimum of three samples shall be taken even if the road is less than one mile long. Section 4.3 describes some of the possible sampling apparatus used to collect the grab samples.

Grab samples shall not contain underlying soils. Each of the grab samples shall be placed in the same sample container. This composited sample shall be crushed to produce a material with a nominal size of less than three-eighths of an inch. Before crushing, the sample must be adequately dried. ASTM Method C-702-80, which is incorporated herein by reference, shall be used to reduce the size of the crushed grab sample to a one pint aliquot. The one pint aliquot shall be further crushed using a Bruan mill or equivalent to produce a material which the majority of which shall be less than 200 Tyler mesh. An aliquot of the 200 mesh material shall be put into a labeled sealed container. The label must contain all the information listed in Section 6 (except item 4).

5.3.3 Serpentine Aggregate Covered Road Shoulders

The sampling procedure specified in Section 5.3.1 or 5.3.2 shall be used for road shoulders covered with serpentine aggregate. The only difference is that a minimum of three grab samples shall be taken over a length of two miles of shoulder or over an area of two acres of shoulder surface. The word shoulder is meant to imply shoulders on both sides of the road. For serpentine aggregated covered shoulders, the sampling plan specified in Section 5 shall indicate whether the samples are collected on a two mile or two acre basis.

6 SAMPLING LOG

A sample log must be kept showing:

1) A unique sample number.
2) Facility name.
3) Facility address or location where sample is taken.
4) A rough sketch, video tape, or photograph of the specific sampling locations.
5) Date and time of sampling.
6) Name of person performing sampling.

7 ANALYTICAL PROCEDURES

7.1 Principle and Applicability.

Samples of serpentine aggregate taken for asbestos identification are first examined for homogeneity and preliminary fiber identification at low magnification. Positive identification of suspect fibers is made by analysis of subsamples with the polarized light microscope.

The principles of optical mineralogy are well established.[2,3] A light microscope equipped with two polarizing filters coupled with dispersion staining is used to observe specific optical characteristics of a sample. The use of plane polarized light allows the determination of refractive indices along specific crystallographic axes. Morphology and color are also observed. A retardation plate is placed in the polarized light path for determination of the sign of elongation using orthoscopic illumination. Orientation of the two filters such that their vibration planes are perpendicular (cross polars) allows observation of the birefringence and extinction characteristics of anisotropic particles.

Quantitative analysis involves the use of point counting. Point counting is a standard technique in petrography for determining the relative areas occupied by separate minerals in thin sections of rock. Background information on the use of point counting[3] and the interpretation of point count data[4] is available.

This method is applicable to all bulk samples of serpentine aggregate submitted for identification and quantification of asbestos components.

7.2 Range.

The analytical method may be used for analysis of samples containing from 0 to 100 percent asbestos. The upper detection limit is 100 percent. The lower detection limit is 0.25 percent.

7.3 Interferences.

Fibrous organic and inorganic constituents of bulk samples may interfere with the identification and quantitation of the asbestos content. Fine particles of other materials may also adhere to fibers to an extent sufficient to cause confusion in the identification.

7.4 Analytical Uncertainty.

The uncertainty method is two percent if twenty asbestos fibers are counted in a sample of 400 particles. The uncertainty of the analytical method may be assessed by a 95% confidence interval for the true percentage of asbestos fibers in the rock. The number of asbestos fibers in the sample is assumed to have a binomial distribution. If twenty asbestos fibers are found in a sample of 400 particles, a one-sided confidence interval for the true percentage has an upper bound of seven percent or an analytical uncertainty of two percent.[11] The confidence interval used here is an "exact" interval computed directly from the binomial distribution.

7.5 Apparatus.

7.5.1 Microscope. A low-power binocular microscope, preferable stereoscopic, is used to examine the bulk sample as received.

- Microscope: binocular, 10-45X
- Light Source: incandescent, fluorescent, halogen or fiber optic
- Forceps, Dissecting Needles, and Probes

- Glassine Paper, Clean Glass Plate, or Petri dish
- Compound Microscope requirements: A polarized light microscope complete with polarizer, analyzer, port for wave retardation plate, 360° graduated rotating stage, substage condenser, lamp, and lamp iris
- Polarized Light Microscope: described above
- Objective Lenses: 10X
- Dispersion Staining Objective Lens: 10X
- Ocular Lens: 10X
- Eyepiece Reticule: 25 point or 100 point Chalkley Point Array or cross-hair
- Compensator Plate: 550 millimicron retardation
- First Order Red I Compensator: 530 namometers

7.6 Reagents.

Refractive Index Liquids: 1.490 - 1.570, 1.590 - 1.720 in increments of 0.002 or 0.004.

Refractive Index Liquids for Dispersion Staining: High-dispersion series, 1.550, 1.605, 1.630 (optical).

UICC Asbestos Reference Sample Set: Available from UICC MRC Pneumoconiosis Unit, Lisndough Hospital Penarth, Glamorgan CF6 1xw, UK and commercial distributors.

Tremolite-asbestos: Available from J. T. Baker.

Actinolite-asbestos: Available from J. T. Baker.

Chrysotile, Amosite, and Crocidolite is available from the National Institute of Standards and Technology.

Anthrophyllite, Tremolite, Actinolite will be available from the National Institute of Standards and Technology during the first quarter of 1990.

8 PROCEDURES

Exposure to airborne asbestos fibers is a health hazard. Bulk samples submitted for analysis are usually friable and may release fibers during handling or matrix reduction steps. All samples and slide preparations should be carried out in a ventilated hood or glove box with continuous airflow (negative pressure) exhausting through an HEPA filter. Handling of samples without these precautions may result in exposure of the analyst and contamination of samples by airborne fibers.

8.1 Sample Preparation.

An aliquot of bulk material is removed from the one pint sample container. The aliquot is spread out on a glass slide. A drop of staining solution with appropriate refractive index is added to the aliquot. A cover slide is placed on top of the sample slide.

The first preparation should use the refractive index solution for Chrysotile. If during the identification phase other asbestiforms are suspected to be present in the sample, due to their morphology, then additional analyses shall be performed with the appropriate solutions. Report the percentages of each asbestiform and combine percentages to determine total asbestos concentrations.

8.2 Fiber Identification.

Positive identification of asbestos requires the determination of the following optical properties:

Morphology (3 to 1 minimum aspect ratio)
Color and plechroism
Refractive indices
Birefringence
Extinction characteristics
Sign of elongation

Table 3 lists the above properties for commercial asbestos fibers. Natural variations in the conditions under which deposits of asbestiform minerals are formed will occasionally produce exceptions to the published values and differences from the UICC standards. The sign of elongation is determined by use of the compensator plate and crossed polars. Refractive indices may be determined by the Becke line test. Becke line test or dispersion staining shall be used to identify asbestos fibers. Central stop dispersion staining colors are presented in Table 4. Available high-dispersion (HD) liquids should be used.

8.3 Quantification of Asbestos Content.

Asbestos quantification is performed by a point-counting procedure. An ocular reticle (point array) or cross-hair is used to visually superimpose points on the microscope field of view. The point counting rules are as follows:

1. Record the number of points positioned directly above each particle or fiber.

2. Record only one point if two points are positioned over same particle or fiber.

3. Record the number of points positioned on the edge of a particle or fiber.

4. If an asbestos fiber and a matrix particle overlap so that a point is superimposed on their visual intersection, a point is scored for both categories.

5. If a test point lies over an ambiguous structure, no particle or fiber is recorded. Examples of "ambiguous" structures are:

   a) fibers whose dispersion colors are difficult to see

   b) structures too small to categorize.

6. A fiber mat or bundle is counted as one fiber.

For the purpose of the method, "asbestos fibers" are defined as mineral fibers having an aspect ratio greater than 3:1 and being positively identified as one of the minerals in Table 3.

A total of 400 points superimposed on either asbestos fibers or nonasbestos matrix material must be counted over at least eight different preparations of representative subsamples. Take eight forceps samples and mount each separately with the appropriate refractive index liquid. The preparation should not be heavily loaded. The sample should be uniformly dispersed to avoid overlapping particles and allow 25 - 50 percent empty area within the fields of view. Count 50 nonempty points on each preparation, using either

a reticle with 100 points (Chalkley Point Array) and counting 25 points in at least two randomly selected fields.

or

a reticle with 25 points (Chalkley Point Array) and counting at least two randomly selected fields.

or

a reticle with a standard cross-hair and counting at least 50 randomly selected fields.

For samples with mixtures of isotropic and anisotropic materials present, viewing the sample with slightly uncrossed polars or the addition of the compensator plate to the polarized light path will allow simultaneous discrimination of both particle types. Quantitation should be performed at 100X. Confirmation of the quantitation result by a second analyst on 10 percent of the analyzed samples should be used as standard quality control procedure. All optical properties in Section 8.2 shall be determined to positively identify asbestos.

EXCEPTION I

If the sample is suspected of containing no asbestos a visual technique can be used to report that the sample does not contain asbestos. The rules are as follows:

1. Prepare three slides as described in Section 8.3.
2. View 10 fields per preparation. Identify all fibers.
3. If all fibers are nonasbestos, report no asbestos were found and that visual technique was used.
4. If one fiber is determined to be asbestos, discontinue the visual method and perform the point counting technique as described above.

EXCEPTION II

If the sample is suspected to have an asbestos content in excess of ten percent, a visual technique can be used to report that the sample contains greater than ten percent asbestos. The standard operating procedure of the visual technique allowed in the National Institute of Standards and Technology's National Voluntary Laboratory Accreditation Program, Bulk Asbestos Handbook, National Institute of Standards and Technology publication number NISTIR 88-3879 dated October 1988, which is incorporated herein by reference, shall be followed.

9 CALCULATIONS

The percent asbestos is calculated as follows:

$$\% \text{ asbestos} = \left(\frac{a}{n}\right) 100\%$$

Where:

a = number of asbestos counts
n = number of nonempty points counted (400)
If a = 0, report "No asbestos detected."
If a > 0, report the calculated value to the nearest 0.25%

If "no asbestos detected: is reported by the point counting technique, the analyst may report the observation of asbestos fibers in the non-counted portions of the sample.

10 ALTERNATIVE METHODS

10.1 Alternative Sampling Methods.

Alternative sampling methods may be used as long as they are substantially equivalent to the sampling methods discussed in Section 5 and approved by the Executive Officer of the Air Resources Board. The ARB Executive Offcier may require the submittal of test data or otehr information to demonstrate equivalency.

10.2 Analytical Methods.

An alternative analytical method may be used as longas it produces results substantially equivalent to the results produced by the point counting method and approved by the Executive Officer of the Air Resources Board. The ARB Executive Officer may require the submittal of test data or other information to demonstrate equivalency.

11 REFERENCES

11.1 G. S. Koch, Jr., R. F. Link. Statistical Analysis of Geological Data. New York. Dover Publications, Inc. December 1985.

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11.5 E. P. Brantly, Jr., K. W. Gold, I. E. Myers, and D. E. Lentzen. Bulk Sample Analysis for Asbestos Content: Evaluation of the Tentative Method. U. S. Environmental Protection Agency. October 1981.

11.6 U. S. Environmental Protection Agency. Asbestos-Containing Materials in School Buildings: A Guidance Document, Parts 1 and 2 EPA/OTS No. C00090m Narcg. 1979.

11.7 D. Lucas, T. Harwell, and A. V. Rao. Asbestos Containing Materials in Schoold Buildings: Guidance for Asbestos Analytical Programs, EPA 580/13-80-017a. U. S. Environmental Protection Agency. December 1980.

11.8 D. H. Taylor and J. S. Bloom. Hexametaphosphate Pretreatment of Insulation Samples for Identification of Fibrous Constituents. Microscope, 28. 1980.

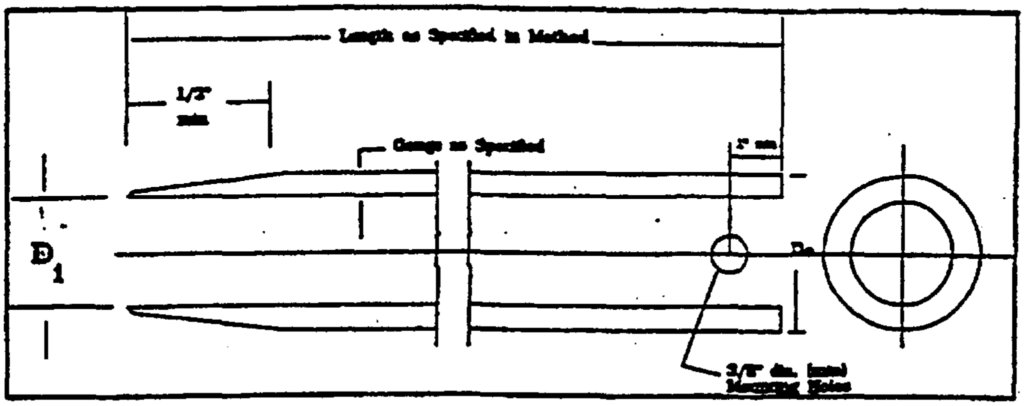
11.9 W. J. Campbell, R. L. Blake, L. L. Brown, E. E. Cather, and J. J. Sjoberg. Selected Silicate Minerals and Their Asbestiform Varieties: Mineralogical Definitions and Identification-Characterization. U. S. Bureau of Mines Information Circular 8751. 1977.

11.10 Walter C. McCrone. Asbestos Particle Atlas. Ann Arbor. Ann Arbor Science Publishers. June 1980.

11.11 John Moore. Biostatician. Personnel Communication. February 8, 1990.

Figure 1

Thin Wall Tube for Sampling



Note 1 Minimum of two mounting holes on opposite sides for 2 to 3 inch diameter sampler.

Note 2 Minimum of four mounting holes spaced at 90° for samplers 4 inch diameter and larger.

Note 3 Tube held with hardened screws.

Note 4 Two inch outside-diameter tubes are specified with an 18-guage wall thickness to comply with area ratio criteria accepted for "undisturbed samples." Users are advised that such tubing is difficult to locate and can be extremely expensive in small quantities. Sixteen-guage tubes are generally readily available.

Table 1

Suitable Thin Walled Steel Sample Tube[A]

OUTSIDE DIAMETER:			
iches	2	3	5
millimeters	50.8	76.2	127
WALL THICKNESS:			
Bwg	18	16	11
inches	0.049	0.065	0.120
millimeters	1.24	1.65	3.05
TUBE LENGTH:			
inches	36	36	54
meters	0.91	0.91	1.45
CLEARNACE RATIO, %	1	1	1

[A] The three diameters recommended in Table 1 are indicated for purposes of standardization, and are not intended to indicate that sampling tubes of intermediate or larger diameters are not acceptable. Lengths of tubes shown are illustrative. Proper lengths to be determined as suited to field conditions.

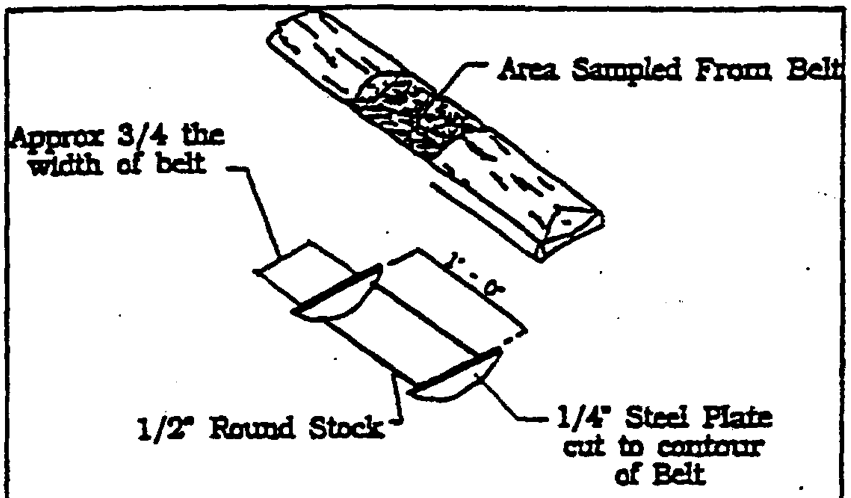
Table 2

Dimensional Tolerances for Thin Walled Tubes

Nominal Tube Diameters from Table 1[A] Toelrances, inches			
Size Outside Diameter	2	3	4
Outside Diameter	+0.007 -0.000	+0.010 -0.000	+0.015 -0.000
Inside Diameter	+0.000 -0.007	+0.000 -0.010	+0.000 -0.015
Wall Thickness	+0.007	+0.010	+0.015
Ovality	0.015	0.020	0.030
Straightness	0.030/ft	0.030/ft	0.030/ft

[A] Intermediate or larger diameters should be proportional. Tolerances shown are essentially standard commercial manufacturing tolerances for seamless steel mechanical tubing. Specify only two of the first three toelrances; O. D. and I. D. or O. D. and Wall, or I. D. and Wall.

Figure 2



Typical Template to Drag Sample Off Belt

Table 3

Optical Properties of Asbestos Fibers

Mineral	Morphology[a], color	Refractive Indices[b] alpha	 gamma	Birefringence	Extinction	Sign of Elongation
Chrysotile (asbestiform serpentine)	Wavy fibers. Fiber bundles have splayed ends and "kinks." Aspect ratio typically >10:1. Colorless[c], nonpleochloric.	1.493 - 1.560	1.517 - 1.562[f] (normally 1.556)	0.002 - 0.014	‖ to fiber length	+ (length slow)
Amosite (asbestiform grunerite)	Straight, rigid fibers. Aspect ratio typically >10:1. Colorless to brown, nonpleochroic or weakly so. Opaque inclusions may be present.	1.635 - 1.696	1.655 - 1.729[f] (normally 1.696 - 1.710)	0.020 - 0.33	‖ to fiber length	+ (length slow)
Crocidolite (asbestiform riebeckite)	Straight, rigid fibers. Thick fibers and bundles common, blue to purple-blue in color. Pleochroic. Birefringence is genreally masked by blue color.	1.654 - 1.701	1.668 - 1.717[e] (normally close to 1.700)	0.014 - 0.016	‖ to fiber length	- (length fast)
Anthophyllite-asbestos	Stright fibers and fiber bundles showing spalyed ends. Colorless to light brown. pleochroic absent.	1.596 - 1.652	1.615 - 1.676[f]	0.019 - 0.024	‖ to fiber length	+ (length slow)
Tremolite-actinolite-asbestos	Straight and curved fibers$_{d}$ and fiber bundles. Large bundles show spalyed ends. Tremolite is colorless and actinolite is green. Weakly to moderately pleochroic.	1.599 - 1.668	1.622 - 1.688[f]	0.023 - 0.020	‖ to fiber length	+ (length slow)

[a] From Reference 6; colors cited are seen by observation with plane polarized light.

[b] From Reference 7 and 9.

[c] Fibers subjected to heating may be brownish.

[d] Fibers defined as having aspect ratio >3:1.

[e] ⊥ to fiber length.

[f] ‖ to fiber length.

Appendix D

Air Resources Board
Asbestos Monitoring Information

Appendix D
Summary of Monitoring Results

1. Asbestos Background Monitoring

The ARB staff conducted asbestos background monitoring at 31 sites in El Dorado, Placer, and Nevada counties. In general, the results of the background air monitoring studies indicated that the public was exposed low levels of asbestos. This was the case at 28 of the 31 background monitoring sites. At the 28 sites, a total of 277 samples were taken; however, only 64 samples had positive results for asbestos. The background asbestos levels measured in those samples ranged from below the minimum detection level to about 0.0017 fibers per cubic centimeter (fiber/cc) of air.

To estimate the average mesothelioma risk and lung cancer risk, the ARB staff averaged the asbestos levels measured at each monitoring site. The estimated cancer risk assumes that a person is breathing these average concentrations for 24 hours a day for 70 years. In cases where the results were below the minimum detection level (MDL), one half of the MDL was used in estimating the risk. The estimated average mesothelioma risk and lung cancer risk for those 28 locations ranged from about one to 10 chances in a million. Potential cancer risks in this level are generally of less of concern to public health officials.

At three remaining background sites, the measured asbestos levels were higher than the other background sites. At these 3 sites, a total of 28 samples were taken and 26 of those samples detected asbestos. The asbestos levels measured at these 3 sites ranged from below the minimum detection level to about 0.0078 fibers/cc. The ARB staff determined that potential sources of asbestos were impacting these sites. These sources included unpaved serpentine roads, driveways, and parking lots, active and inactive quarries in the vicinity, and a homeowner putting serpentine material in and around a horse corral during the monitoring activity. These 3 sites had an estimated mesothelioma risk that is between 10 and 50 chances in a million.

Table D-1 summarizes the monitoring results and the estimated average cancer risk for the 28 background sites. The other 3 background sites impacted by potential sources are also listed in Table D-1, under the near source monitoring results.

2. Asbestos Monitoring Near Sources

The ARB's recent monitoring near potential sources of asbestos was conducted at 33 other sites. The potential sources included active serpentine quarries, near unpaved serpentine roads with local traffic activity, and construction/grading sites in areas with naturally-occurring asbestos. A total of 227 samples were taken as part of the asbestos monitoring near sources; 135 samples had positive results for asbestos. The air monitoring results show individual asbestos levels ranging from below the MDL to 0.169 fibers/cc at the entrance to an active serpentine quarry.

Near these potential sources, the associated average cancer risk is typically between 10 and 50 chances in a million. However, the average concentration at one site near the entrance to a serpentine quarry was 0.05 fibers/cc. At that level, the average mesothelioma risk is estimated to be about 300 chances in a million.

In addition, the ARB staff conducted air monitoring near a construction site and a site where asbestos-contaminated dirt piles were being removed and transported to a landfill. The asbestos levels detected were low and the associated cancer risk is estimated to be below 10 chances in a million. The low asbestos levels may be attributed to good dust mitigation measures being utilized, such as watering, and/or to the precipitation occurring prior to the start of the monitoring efforts.

A summary of the asbestos monitoring results and the associated average cancer risk is provided in Table D-1. The results of the ARB's background and near source asbestos monitoring can be found in this appendix or can be obtained from the ARB web site.

Table D-1
Summary of 1998-1999 Asbestos Monitoring Results[1] and Associated Cancer Risk in El Dorado, Placer, and Nevada Counties

Location	No. Of Sites	No. Of Samples	No. of Samples Above MDL[2]	Range of Average Risk[3] by Site (chances per million)	
				Mesothelioma	Lung Cancer
Background					
El Dorado County	21	252	57	1 – 10	1 – 6
Placer/Nevada County	7	25	7	3 – 8	2 – 5
Near Sources					
El Dorado County[4]	3	28	26	10 – 50	7 – 30
Monitoring Near Quarry	7	110	87	22 - 290	13 – 170
Garden Valley	7	38	32	10 – 45	6 – 30
Foresthill	3	9	9	7 – 80	4 – 50
Nevada County	1	3	2	2 – 30	1 – 20
El Dorado Hills[5]	7	35	5	3 – 5	2 – 3
Woedee Drive Area[5]	8	32	0	2	1

1. Information on the monitoring results is contained in this appendix.
2. MDL means minimum detection level.
3. When calculating the range of average risk by site, the concentrations of samples below the MDL were assumed to be half of the MDL.
4. Background sites impacted by potential sources.
5. Dust controls and/or wet grounds contributed to low asbestos levels.

California Air Resources Board

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Asbestos Information

This page updated May 12, 2000.

An area has been established to provide information regarding proposed revisions to the Asbestos ATCM ● Go there

General Information

- Updated El Dorado County Map - The Department of Conservation, Division of Mines and Geology has updated the map of (western) El Dorado County showing potential locations of naturally-occurring asbestos. (*Added 05/12/00*) NEW
- Public Advisory on Asbestos-Containing Materials Used on Playgrounds and Other Surfaces (*Added 01/00*)
- Asbestos Fact Sheets (*Updated 12/99*)
- Asbestos Task Force: Findings and Recommendations on Naturally-Occurring Asbestos to El Dorado County (*Added 3/12/99*)
- Asbestos Air Monitoring in El Dorado County, California - Includes measured ambient asbestos concentrations through **mid-Winter 2000** (*Updated 05/12/00*) UPDATED
- Asbestos Air Monitoring in Placer and Nevada Counties, California - Includes measured ambient asbestos concentrations through **Summer 1999** (*Updated 9/15/99*)
- White Paper - Naturally-Occurring Asbestos in El Dorado County
- Map of California showing principal asbestos deposits

Regulatory Information

- Asbestos Airborne Toxic Control Measure (ATCM) for Asbestos-Containing Serpentine
- ARB Test Method 435 - Determination of Asbestos Content in Serpentine Aggregate (Acrobat - 80K) or (WP6.1 - 839K)
- U.S. EPA Asbestos NESHAP (Acrobat - 400K) or (ASCII - 119K)
- ARB Asbestos NESHAP Program (incl. the Demolition/Renovation Notification Form)
- Common Questions on the U.S. EPA Asbestos NESHAP

Related Links

- General Asbestos Information - From U.S. EPA Region 6 - Includes additional links
- Asbestos In Your Home - A report from the American Lung Association and U.S. EPA
- American Lung Association Asbestos Fact Sheet
- Agency for Toxic Substances and Disease Registry - Toxicity/exposure information
- U.S. EPA Unified Air Toxics Website - Toxicity information

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California Air Resources Board

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Asbestos Air Monitoring in El Dorado County

This page updated May 12, 2000.

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The Air Resources Board (ARB) is conducting air monitoring in El Dorado County to determine the levels, or concentration, of asbestos in the air at selected sites. This monitoring data will be used to help evaluate the extent of the public's exposure to asbestos.

WHERE IS THE MONITORING BEING CONDUCTED?

Monitoring is currently being conducted in various locations in El Dorado County. The sites are selected to provide data on the concentrations of asbestos that may be present in the vicinity of a particular site, and in some cases, may represent "worst case" conditions. The ARB welcomes suggestions by the public for possible monitoring site locations.

WHEN DID THE ARB START MONITORING?

Monitoring was started on April 21, 1998. No monitoring is conducted when it is raining and only resumes after 72 hours of dry conditions.

HOW ARE THE SAMPLES COLLECTED AND ANALYZED?

The monitor is a portable unit which consists of a battery operated pump and a filter designed for asbestos air monitoring. Air is drawn through the filter continuously over a 24 hour period. The filters are analyzed by United States Environmental Protection Agency procedures. The analysis uses transmission electron microscopy, a state-of-the-art technique, to identify the fibers as asbestos and to count the asbestos fibers on a small section of filter. The concentration is determined by dividing the number of fibers caught on the filter in a 24 hour period by the volume of air drawn through the unit in that time period. The samples are analyzed by a laboratory under contract to the ARB and certified by the National Institute of Standards and Technology's National Voluntary Laboratory Accreditation Program. Quality control measures and chain of custody procedures are followed in both the field and laboratory for all samples collected.

WHAT ARE THE RESULTS?

General Asbestos Monitoring

Detailed sampling results from April 21 through October 18, 1998 are listed in Table 1. The table will be updated regularly as new data become available. For a quick summary of results, click here.

One hundred ninety-five of the 252 results monitored during the sampling period were found to be below the minimum detection limit (MDL). The MDL is the level below which you cannot accurately quantify the amount of the substance being sampled. For example, you cannot accurately weigh anything below a pound on your typical bathroom scale. The MDL for asbestos can vary depending upon the volume of air which is drawn through the filter and the amount of the filter analyzed. The ARB is currently working on lowering the MDL for asbestos so that lower concentrations can be accurately measured.

Asbestos Monitoring near a Potential Asbestos Source

During October 1998, the ARB conducted ambient monitoring generally near a potential asbestos source in El Dorado County. Air samples were taken at seven separate monitoring locations near an operating serpentine quarry from October 2 through October 18, 1998. Eighty-seven of the 110 results monitored during the sampling period were found to be above the MDL. The 87 sampling results (detailed listing) are presented in the attached Table 2. For a quick summary of results, click here.

Asbestos Monitoring in Silva Valley

During April 1999, the ARB conducted ambient monitoring in the Silva Valley area of El Dorado County. Air samples were taken at seven separate monitoring locations from April 21 through April 29, 1999. Five of the 35 results monitored during the sampling period were found to be above the MDL. The 35 sampling results (detailed listing) are presented in the attached Table 3. For a quick summary of results, click here.

Asbestos Monitoring in Garden Valley

During August 1999, the ARB also conducted ambient monitoring in the Garden Valley area of El Dorado County. Air samples were taken at seven separate monitoring locations from August 16 through August 26, 1999. Thirty-two of the 38 results monitored during the sampling period were found to be above the MDL. The 38 sampling results (detailed listing) are presented in the attached Table 4. For just a quick summary of results, click here.

Asbestos Monitoring Around Woedee Drive

In January 2000, the ARB conducted ambient monitoring around Woedee Drive. Air samples were taken at four separate monitoring locations from January 7 through January 10, 2000. None of the samples collected were found to be above the MDL. A detailed listing of the results is presented in Table 5. For a quick summary of results, click here.

Asbestos Monitoring During Pile Removal Project on Woedee Drive

The ARB conducted additional ambient monitoring in the Woedee Drive area during the removal of asbestos-containing dirt piles. Air samples were taken at four separate monitoring locations surrounding a vacant lot where the piles were located on February 8, 2000 and February 9, 2000. None of the samples collected were found to be above the MDL. A detailed listing of the results is presented in Table 6. For a quick summary of results, click here.

WHAT DO THE SAMPLING RESULTS MEAN?

It is important to understand that these sampling results are individual measurements at specific sites and do not represent what the average or typical asbestos exposures may be in El Dorado County. The ARB has estimated the potential cancer risks associated with the 57 individual sampling results which were above the MDL for the general asbestos monitoring (Table 1). The estimated risk numbers, when averaged at each site, ranged from 0 to 50 potential mesothelioma cases in a million and 1 to 30 potential lung cancer cases in a million. These estimated potential cancer risks assume that a person would be continuously breathing those levels for 24 hours a day for 70 years. The greatest estimated lung cancer and mesothelioma risk associated with the levels detected in the samples analyzed to date are about 125 and 220 chances per million, respectively.

The ARB has also estimated the potential risks associated with the samples taken near a potential asbestos source, a serpentine quarry (Table 2). The estimated risk numbers, when averaged at each site, ranged from 22 to 290 potential mesothelioma cases in a million and 13 to 170 potential lung cancer cases in a million. These estimated potential cancer risks assume that a person would be continuously breathing those levels for 24 hours a day for 70 years. Only one location had an average risk higher than 100 in a million, which was at the entrance to the quarry. These risk numbers are preliminary, based on limited data, and should not be used to characterize the potential risk until additional data are gathered.

The estimated risks from the most recent sampling near Garden Valley (Table 4), when averaged at each site, ranged from 13 to 45 potential mesothelioma cases in a million and 8 to 26 potential lung cancer cases in a million. Again, these estimated potential cancer risks assume that a person would be continuously breathing those levels for 24 hours a day for 70 years.

These risk numbers are offered for these individual samples to provide a relative indication of the potential health risk. To put these numbers into further perspective, the estimated background cancer risk from air toxics in a large urban area is estimated to be about 500 chances in a million. An individual's chances of getting cancer over his or her lifetime from all causes is estimated to be about 1 in 5 in California, or 200,000 chances in a million.

NEED MORE INFORMATION?

If you have questions or need more technical information on the ARB asbestos monitoring program, please contact either of the following individuals:

George Lew	(916) 327-0900	glew@arb.ca.gov
Cindy Castronovo	(916) 322-8957	ccastron@arb.ca.gov

If you would like to suggest monitoring site locations or have questions regarding the potential health risks, please contact:

Todd Wong	(916) 322-8285	twong@arb.ca.gov

Measured Ambient Asbestos Concentrations in El Dorado County
General Asbestos Monitoring
(Updated January 15, 1999)

You may also view a detailed listing, which includes asbestos concentrations and sampling dates.

Sampling Period: April 21, 1998 through October 18, 1998

Location	Geographical Area	Number of Samples Analyzed to-date	Number of Samples Detecting Asbestos
Deer Creek Water Treatment Plant	Cameron Park	11	0
Bass Lake Facility	Bass Lake	10	1
Water Tank	Greenstone area	32	17
Fire Station #1	El Dorado Hill	9	1
Fire Station #2	El Dorado Hill	6	1
Georgetown Elementary School	Georgetown	14	2
Golden Sierra High School	Garden Valley	6	3
Greenvalley Elementary School	Cameron Park	6	0
Horse Stables	Auburn Trails Subdivision	9	2
Latrobe Fire Station	Latrobe	17	5
Marina Village Intermediate School	El Dorado Hills	12	3
Northside Elementary School	Cool	9	2
Oakridge High School	El Dorado Hills	6	0
Pacific House Ranger Station	Freshpond	33	3
Ponderosa High School	Shingle Springs	6	0
Private Residence	Bridlewood Subdivision	6	1
Private Residences	Cothrin Ranch Subdivision	30	3
Private Residence	Rescue	9	9
Private Residence	Lake Hills Estates	12	1
Sutters Mill Elementary School	Lotus	9	3
	Totals:	252	57

Measured Ambient Asbestos Concentrations in El Dorado County
Asbestos Monitoring Near a Potential Asbestos Source

(Updated January 15, 1999)

You may also view a detailed listing, which includes asbestos concentrations and sampling dates.

Sampling Period: October 1, 1998 through October 18, 1998

Location	Geographical Area	Number of Samples Analyzed to-date	Number of Samples Detecting Asbestos
Private Parcel #1	Lotus	15	12
Private Residence #1	Lotus	14	10
Private Parcel #2	Lotus	13	12
Private Parcel #3	Lotus	15	11
Private Residence #1	Greenstone Subdivision	16	11
Private Residence #2	Greenstone Subdivision	13	8
Entrance to Quarry	Lotus	24	23
	Totals:	110	87

Measured Ambient Asbestos Concentrations in El Dorado County
Asbestos Monitoring in Silva Valley
(Updated September 15, 1999)

You may also view a detailed listing, which includes asbestos concentrations and sampling dates.

Sampling Period: April 21, 1999 through April 29, 1999

Location	Geographical Area	Number of Samples Analyzed to-date	Number of Samples Detecting Asbestos
Oak Ridge High School - Site 1	El Dorado Hills	5	0
Oak Ridge High School - Site 2	El Dorado Hills	5	1
Silva Elementary School - Site 1	El Dorado Hills	5	0
Silva Elementary School - Site 2	El Dorado Hills	5	1
Silva Elementary School - Site 3	El Dorado Hills	5	1
Silva Elementary School - Site 4	El Dorado Hills	5	2
Construction Site	El Dorado Hills	5	0
	Totals:	35	5

Measured Ambient Asbestos Concentrations in El Dorado County
Asbestos Monitoring in Garden Valley
(Updated December 10, 1999)

You may also view a detailed listing, which includes asbestos concentrations and sampling dates.

Sampling Period: August 16, 1999 through August 26, 1999

Location	Geographical Area	Number of Samples Analyzed to-date	Number of Samples Detecting Asbestos
Golden Sierra High School	Garden Valley	4	4
Garden Valley Park	Garden Valley	4	3
Garden Valley Site #1	Garden Valley	6	5
Garden Valley Site #2	Garden Valley	6	5
Garden Valley Site #3	Garden Valley	6	5
Garden Valley Site #4	Garden Valley	6	6
Garden Valley Site #5	Garden Valley	6	4
	Totals:	38	32

Measured Ambient Asbestos Concentrations in El Dorado County
Asbestos Monitoring Around Woedee Drive
(Updated May 12, 2000)

You may also view a detailed listing, which includes asbestos concentrations and sampling dates.

Sampling Period: January 7, 2000 through January 10, 2000

Location	Geographical Area	Number of Samples Analyzed to-date	Number of Samples Detecting Asbestos
Vacant Lot	Woedee Drive	6	0
Construction Site	Woedee Drive	5	0
Community Center Pool	Woedee Drive	5	0
Bass Lake	Woedee Drive	6	0
	Totals:	22	0

Measured Ambient Asbestos Concentrations in El Dorado County
Asbestos Monitoring During Pile Removal Project on Woedee Drive

(Updated May 12, 2000)

You may also view a detailed listing, which includes
asbestos concentrations and sampling dates.

Sampling Period: February 8, 2000 and February 9, 2000

Location	Geographical Area	Number of Samples Analyzed to-date	Number of Samples Detecting Asbestos
East	Woedee Drive	2	0
North	Woedee Drive	2	0
South	Woedee Drive	2	0
West	Woedee Drive	2	0
	Totals:	8	0

Asbestos fiber analysis by Transmission Electron Microscopy (TEM) performed by EPA 40 CFR Part 763 Final Rule (AHERA).

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Table 1
Measured Ambient Asbestos Concentrations in El Dorado County, California

This page updated January 15, 1999.

Table 1 - Detailed Listing - Page 1 of 2

(Updated January 15, 1999)

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Note: Recently added data is shown in italics.

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Location Name	Geographical Area/City	Sampling Dates	Concentration (fibers per cc)		Log Number
			Measured[2]	MDL[6]	
Deer Creek Waste Water Treatment Plant	Cameron Park	06/01/98 - 06/02/98	ND	0.000747	ELD-44
		06/02/98 - 06/03/98	ND	0.001866	ELD-47
		06/10/98[3] - 06/11/98	ND	0.000735	ELD-63
		06/10/98[3] - 06/11/98	ND	0.000715	ELD-64
		06/11/98[3] - 06/12/98	ND	0.000740	ELD-65
		06/11/98[3] - 06/12/98	ND	0.000735	ELD-66
		06/15/98[3] - 06/16/98	ND	0.000745	ELD-72
		06/15/98[3] - 06/16/98	ND	0.000733	ELD-73
		09/21/98 - 09/22/98	ND	0.000803	ELD-223
		09/22/98 - 09/23/98	ND	0.000791	ELD-235
		09/23/98 - 09/24/98	ND	0.000802	ELD-250
EID Bass Lake Facility	Bass Lake	06/15/98 - 06/16/98	ND	0.000747	ELD-69
		06/16/98 - 06/17/98	ND	0.000747	ELD-78
		06/17/98 - 06/18/98	ND	0.001211	ELD-83
		06/18/98 - 06/19/98	ND	0.000960	ELD-88
		06/30/98 - 07/01/98	0.000971	0.000971	ELD-95
		07/01/98 - 07/0//98	ND	0.000972	ELD-102
		07/02/98 - 07/03/98	ND	0.001005	ELD-107
		09/21/98 - 09/22/98	ND	0.000799	ELD-221
		09/22/98 - 09/23/98	ND	0.000795	ELD-234
		09/23/98 - 09/24/98	ND	0.000787	ELD-248
EID Water Tank	Greenstone Area	04/28/98 - 04/29/98	ND	0.002034	ELD-21

		04/29/98 - 04/30/98	ND	0.001868	ELD-26
		04/30/98 - 05/01/98	ND	0.001972	ELD-31
		09/08/98 - 09/10/98	ND	0.000936	ELD-191
		09/09/98 - 09/10/98	ND	0.000940	ELD-199
		09/10/98 - 09/11/98	ND	0.000993	ELD-207
		10/01 - 10/02/98	*0.000809*	*0.000809*	*S9-1*
		10/02 - 10/03/98	*ND*	*0.000789*	*S9-2*
		10/03 - 10/04/98	*ND*	*0.000791*	*S9-3*
		10/04 - 10/05/98	*0.00155*	*0.00078*	*S9-4*
		10/06 - 10/07/98	*0.00625*	*0.000782*	*S9-5*
		10/07 - 10/08/98	*0.00903*	*0.00451*	*S9-6*
		10/08 - 10/09/98	*0.0326*	*0.00163*	*S9-7*
		10/09 - 10/10/98	*0.00155*	*0.00078*	*S9-8*
		10/10 - 10/11/98	*0.000768*	*0.000768*	*S9-9*
		10/11 - 10/12/98	*ND*	*0.000769*	*S9-10*
		10/12 - 10/13/98	*ND*	*0.000805*	*S9-11*
		10/13 - 10/14/98	*0.0064*	*0.000801*	*S9-12*
		10/17 - 10/18/98	*0.000786*	*0.000786*	*S9-13*
		10/01 - 10/02/98	*ND*	*0.000809*	*S9-1-R*
		10/02 - 10/03/98	*ND*	*0.000789*	*S9-2-R*
		10/03 - 10/04/98	*ND*	*0.000791*	*S9-3-R*
		10/04 - 10/05/98	*ND*	*0.00078*	*S9-4-R*
		10/06 - 10/07/98	*0.00156*	*0.000782*	*S9-5-R*
		10/07 - 10/08/98	*0.0135*	*0.00451*	*S9-6-R*
		10/08 - 10/09/98	*0.0293*	*0.00163*	*S9-7-R*
		10/09 - 10/10/98	*ND*	*0.00078*	*S9-8-R*
		10/10 - 10/11/98	*0.00307*	*0.000768*	*S9-9-R*
		10/11 - 10/12/98	*0.00153*	*0.000769*	*S9-10-R*
		10/12 - 10/13/98	*0.000805*	*0.000805*	*S9-11-R*
		10/13 - 10/14/98	*0.0024*	*0.000801*	*S9-12-R*
		10/17 - 10/18/98	*0.000786*	*0.000786*	*S9-13-R*
El Dorado Hills Fire Station #1	El Dorado Hills	04/21/98[3] - 04/22/98	ND	0.001956	ELD-2
		04/21/98[3] - 04/22/98	ND	0.002120	ELD-3
		04/22/98[3] - 04/23/98	ND	0.003490	ELD-7
		04/22/98[3] - 04/23/98	ND	0.002583	ELD-8
		04/27/98[3] - 04/28/98	ND	0.001864	ELD-12
		04/27/98[3] - 04/28/98	ND	0.001791	ELD-13
		09/21/98 - 09/22/98	ND	0.000805	ELD-219
		09/22/98 - 09/23/98	ND	0.000790	ELD-233
		09/23/98 - 09/24/98	0.00785	0.00785	ELD-247

El Dorado Hills Fire Station #2	El Dorado Hills	07/06/98 - 07/07/98	ND	0.001036	ELD-117
		07/07/98 - 07/08/98	ND	0.000993	ELD-127
		07/08/98 - 07/09/98	ND	0.000949	ELD-136
		09/21/98 - 09/22/98	ND	0.000816	ELD-217
		09/22/98 - 09/23/98	0.000788	0.000788	ELD-231
		09/23/98 - 09/24/98	ND	0.000791	ELD-245
Georgetown Elementary School	Georgetown	06/16/98[3] - 06/17/98	ND	0.000741	ELD-80
		06/16/98[3] - 06/17/98	ND	0.000745	ELD-81
		06/17/98 - 06/18/98	ND	0.001360	ELD-85
		06/18/98[3] - 06/19/98	ND	0.001087	ELD-90
		06/18/98[3] - 06/19/98	ND	0.001201	ELD-91
		06/30/98[3] - 07/01/98	ND	0.000988	ELD-98
		06/30/98[3] - 07/01/98	0.000964	0.000964	ELD-99
		07/01/98[3] - 07/02/98	ND	0.000988	ELD-105
		07/01/98[3] - 07/02/98	ND	0.001005	ELD-106
		07/02/98[3] - 07/03/98	ND	0.000983	ELD-110
		07/02/98[3] - 07/03/98	ND	0.000988	ELD-111
		09/08/98 - 09/09/98	ND	0.000936	ELD-187
		09/09/98 - 09/10/98	ND	0.000919	ELD-195
		09/10/98 - 09/11/98	0.002975	0.000992	ELD-203
Golden Sierra High School	Garden Valley	04/28/98 - 04/29/98	ND	0.002014	ELD-20
		04/29/98 - 04/30/98	0.001882	0.001882	ELD-25
		04/30/98 - 05/01/98	ND	0.001953	ELD-30
		09/08/98 - 09/09/98	ND	0.000936	ELD-188
		09/09/98 - 09/10/98	0.000938	0.000938	ELD-196
		09/10/98 - 09/11/98	0.006194	0.001032	ELD-204
Greenvalley Elementary School	Cameron Park	04/21/98 - 04/22/98	ND	0.001742	ELD-4
		04/22/98 - 04/23/98	ND	0.002301	ELD-9
		04/27/98 - 04/28/98	ND	0.001775	ELD-14
		09/21/98 - 09/22/98	ND	0.00786	ELD-213
		09/22/98 - 09/23/98	ND	0.000785	ELD-227
		09/23/98 - 09/24/98	ND	0.000786	ELD-241
Horse Stables Parking Lot	Auburn Trails Subdivision	06/16/98 - 06/17/98	ND	0.000731	ELD-79
		06/17/98 - 06/18/98	ND	0.000821	ELD-84
		06/18/98 - 06/19/98	ND	0.001047	ELD-89
		06/30/98 - 07/01/98	ND	0.000971	ELD-97

		07/01/98 - 07/02/98	ND	0.000980	ELD-104
		07/02/98 - 07/03/98	ND	0.000988	ELD-109
		09/08/98 - 09/09/98	0.000950	0.000950	ELD-186
		09/09/98 - 09/10/98	ND	0.000937	ELD-194
		09/10/98 - 09/11/98	0.001001	0.001001	ELD-202
Latrobe Fire Station	Latrobe	04/21/98 - 04/22/98	ND	0.001816	ELD-1
		04/22/98 - 04/23/98	ND	0.002201	ELD-6
		04/27/98 - 04/28/98	0.001439	0.001439	ELD-11
		06/01/98[3] - 06/02/98	ND	0.000729	ELD-35
		06/01/98[3] - 06/02/98	ND	0.000763	ELD-36
		06/02/98[3] - 06/03/98	ND	0.000733	ELD-46
		06/03/98[3] - 06/04/98	ND	0.000720	ELD-51
		06/03/98[3] - 06/04/98	ND	0.000735	ELD-52
		06/10/98 - 06/11/98	ND	0.000723	ELD-55
		06/11/98 - 06/12/98	ND	0.000718	ELD-56
		06/15/98 - 06/16/98	ND	0.001987	ELD-74
		07/06/98 - 07/08/98	ND	0.001011	ELD-118
		07/07/98 - 07/08/98	ND	0.000983	ELD-132
		07/08/98 - 07/09/98	0.000977	0.000977	ELD-141
		08/24/98 - 08/25/98	0.004834	0.000967	ELD-159
		08/25/98 - 08/26/98	0.003038	0.001013	ELD-167
		08/26/98 - 08/27/98	0.005700	0.000950	ELD-175

NOTES:

1. Asbestos fiber analysis by Transmission Electron Microscopy (TEM) performed by EPA 40 CFR Part 763 Final Rule (AHERA).
2. ND stands for None Detected.
3. Site of co-located samplers.
4. Box Blank is where an unused cartridge is removed from the box of unused filters and sent to the lab for analysis.
5. A field blank is where an unused cartridge is attached to a sampling train and the flow rate is measured. The cartridge is then sealed and sent to the lab for analysis.
6. MDL means Minimum Detection Limit.

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Asbestos Air Monitoring

A department of the California Environmental Protection Agency

Table 1
Measured Ambient Asbestos Concentrations in El Dorado County, California

This page updated January 15, 1999.

Table 1 - Detailed Listing - Page 2 of 2

(Updated January 15, 1999)

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Note: Recently added data is shown in italics.

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Location Name	Geographical Area/City	Sampling Dates	Concentration (fibers per cc)		Log Number
			Measured^2	MDL^6	
Marina Village Intermediate School	El Dorado Hills	06/30/98 - 07/01/98	ND	0.000983	ELD-96
		07/01/98 - 07/02/98	ND	0.000998	ELD-103
		07/02/98 - 07/03/98	ND	0.000996	ELD-108
		07/06/98^3 - 07/07/98	ND	0.001038	ELD-115
		07/06/98^3 - 07/07/98	ND	0.001058	ELD-116
		07/07/98^3 - 07/08/98	ND	0.001075	ELD-125
		07/07/98^3 - 07/08/98	0.000977	0.000977	ELD-126
		07/08/98^3 - 07/09/98	0.000988	0.000988	ELD-134
		07/08/98^3 - 07/09/98	ND	0.001239	ELD-135
		09/21/98 - 09/22/98	ND	0.000793	ELD-216
		09/22/98 - 09/23/98	ND	0.000800	ELD-230
		09/23/98 - 09/24/98	0.000796	0.000796	ELD-244
Northside Elementary School	Cool	04/28/98^3 - 04/29/98	ND	0.001800	ELD-18
		04/28/98^3 - 04/29/98	ND	0.001779	ELD-19
		04/29/98^3 - 04/30/98	ND	0.001737	ELD-23
		04/29/98^3 - 04/30/98	ND	0.001721	ELD-24
		04/30/98^3 - 05/01/98	0.001872	0.001872	ELD-28
		04/30/98^3 - 05/01/98	ND	0.001883	ELD-29
		09/08/98 - 09/09/98	0.000936	0.000936	ELD-185
		09/09/98 - 09/10/98	ND	0.000919	ELD-193
		09/10/98 - 09/11/98	ND	0.000994	ELD-201

Oakridge High School	El Dorado Hills	06/01/98 - 06/02/98	ND	0.000762	ELD-37
		06/02/98 - 06/03/98	ND	0.000733	ELD-38
		06/03/98 - 06/04/98	ND	0.000726	ELD-39
		09/21/98 - 09/22/98	ND	0.000817	ELD-218
		09/22/98- 09/23/98	ND	0.000788	ELD-323
		09/23/98 - 09/24/98	ND	0.000791	ELD-246
Pacific House Ranger Station	Freshpond	04/21/98 - 04/22/98	ND	0.001967	ELD-5
		04/22/98 - 04/23/98	ND	0.002749	ELD-10
		04/27/98 - 04/28/98	ND	0.001809	ELD-15
		04/28/98 - 04/29/98	ND	0.001893	ELD-22
		04/29/98 - 04/30/98	ND	0.001806	ELD-27
		04/30/98 - 05/01/98	ND	0.001847	ELD-32
		06/01/98 - 06/02/98	ND	0.000720	ELD-43
		06/02/98 - 06/03/98	ND	0.001820	ELD-48
		06/03/98 - 06/04/98	ND	0.000739	ELD-49
		06/10/98 - 06/11/98	ND	0.000978	ELD-67
		06/11/98 - 06/12/98	ND	0.001579	ELD-68
		06/15/98 - 06/16/98	ND	0.000767	ELD-71
		06/16/98 - 06/17/98	ND	0.000884	ELD-82
		06/17/98 - 06/18/98	ND	0.001537	ELD-87
		06/18/98 - 06/19/98	0.001375	0.001375	ELD-92
		06/30/98[3]- 07/01/98	ND	0.000972	ELD-100
		06/30/98[3] - 07/01/98	ND	0.000987	ELD-101
		07/02/98 - 07/03/98	ND	0.000943	ELD-112
		07/06/98 - 07/07/98	ND	0.001032	ELD-123
		07/07/98 - 07/08/98	ND	0.000974	ELD-124
		07/08/98 - 07/09/98	ND	0.002685	ELD-133
		08/04/98 - 08/05/98	ND	0.000975	ELD-144
		08/05/98 - 08/06/98	ND	0.000935	ELD-148
		08/06/98 - 08/07/98	ND	0.000971	ELD-152
		08/24/98 - 08/25/98	0.000994	0.000994	ELD-158
		08/25/98 - 08/26/98	ND	0.000949	ELD-166
		08/26/98 - 08/27/98	ND	0.000928	ELD-174
		09/08/98 - 09/09/98	ND	0.000916	ELD-184
		09/09/98 - 09/10/98	ND	0.000989	ELD-192
		09/10/98 - 09/11/98	ND	0.001059	ELD-200
		09/21/98 - 09/22/98	0.001597	0.000799	ELD-210
		09/22/98 - 09/23/98	ND	0.000833	ELD-224
		09/23/98 - 09/24/98	ND	0.000777	ELD-238
Ponderosa High School	Shingle Springs	06/01/98 - 06/02/98	ND	0.000752	ELD-40
		06/02/98 - 06/03/98	ND	0.000841	ELD-41

		06/03/98 - 06/04/98	ND	0.000743	ELD-42
		09/21/98 - 09/22/98	ND	0.000785	ELD-220
		09/22/98 - 09/23/98	ND	0.000789	ELD-237
		09/23/98 - 09/24/98	ND	0.000797	ELD-251
Private Residence #1	Bridlewood Subdivision	06/10/98 - 06/11/98	ND	0.001075	ELD-61
		06/11/98 - 06/12/98	ND	0.000754	ELD-62
		06/15/98 - 06/16/98	ND	0.000747	ELD-75
		09/21/98 - 09/22/98	0.001077	0.001077	ELD-222
		09/22/98 - 09/23/98	ND	0.00786	ELD-236
		09/23/98 - 09/24/98	ND	0.000785	ELD-249
Private Residence #2	Cothrin Ranch Subdivision	07/06/98 - 07/07/98	ND	0.001071	ELD-119
		07/07/98 - 07/08/98	ND	0.000991	ELD-128
		07/08/98 - 07/09/98	ND	0.000982	ELD-137
		08/24/98 - 08/25/98	ND	0.000986	ELD-160
		08/25/98 - 08/26/98	ND	0.000962	ELD-168
		08/26/98 - 08/27/98	ND	0.000975	ELD-176
Private Residence #3	Cothrin Ranch Subdivision	07/06/98 - 07/07/98	ND	0.001042	ELD-120
		07/07/98 - 07/08/98	ND	0.003048	ELD-129
		07/08/98 - 07/09/98	ND	0.002060	ELD-138
		08/24/98 - 08/25/98	ND	0.000941	ELD-161
		08/25/98 - 08/26/98	ND	0.000999	ELD-169
		08/26/98 - 08/27/98	ND	0.000941	ELD-177
Private Residence #4	Cothrin Ranch Subdivision	07/06/98 - 07/07/98	ND	0.000930	ELD-121
		07/07/98 - 07/08/98	0.002287	0.002287	ELD-130
		07/08/98 - 07/09/98	0.007720	0.000965	ELD-139
		08/24/98[3] - 08/25/98	ND	0.000993	ELD-162
		08/24/98[3] - 08/25/98	ND	0.000975	ELD-163
		08/24/98[3] - 08/25/98	ND	0.000973	ELD-164
		08/25/98[3] - 08/26/98	ND	0.000949	ELD-170
		08/25/98[3] - 08/26/98	ND	0.000968	ELD-171
		08/25/98[3] - 08/26/98	ND	0.000983	ELD-172
		08/26/98[3] - 08/27/98	ND	0.00971	ELD-178
		08/26/98[3] - 08/27/98	ND	0.000948	ELD-179
		08/26/98[3] - 08/27/98	0.000975	0.000975	ELD-180

Private Residence #5	Cothrin Ranch Subdivision	07/06/98 - 07/07/98	ND	0.000985	ELD-122
		07/07/98 - 07/08/98	ND	0.000951	ELD-131
		07/08/98 - 07/09/98	ND	0.000977	ELD-140
		08/24/98 - 08/25/98	ND	0.000965	ELD-165
		08/25/98 - 08/26/98	ND	0.000997	ELD-173
		08/26/98 - 08/27/98	ND	0.000951	ELD-181
Private Residence #6	Rescue	08/04/98 - 08/05/98	0.002999	0.001000	ELD-145
		08/05/98 - 08/06/98	0.010367	0.001481	ELD-149
		08/06/98 - 08/07/98	0.006848	0.000978	ELD-153
		09/21/98[3] - 09/22/98	0.006134	0.000767	ELD-211
		09/21/98[3] - 09/22/98	0.004723	0.000787	ELD-212
		09/22/98[3] - 09/23/98	0.001580	0.000790	ELD-225
		09/22/98[3] - 09/23/98	0.001649	0.000824	ELD-226
		09/23/98[3] - 09/24/98	0.007912	0.000791	ELD-239
		09/23/98[3] - 09/24/98	0.036651	0.001145	ELD-240
Private Residence #7	Lake Hills Estates	08/04/98[3] - 09/05/98	ND	0.000983	ELD-146
		08/04/98[3] - 09/05/98	ND	0.00983	ELD-147
		08/05/98[3] - 08/06/98	ND	0.001190	ELD-150
		08/05/98[3] - 08/06/98	ND	0.001222	ELD-151
		08/06/98[3] - 08/07/98	ND	0.000972	ELD-154
		08/06/98[3] - 08/07/98	ND	0.000978	ELD-155
		09/21/98[3] - 09/22/98	ND	0.000788	ELD-214
		09/21/98[3] - 09/22/98	ND	0.000784	ELD-215
		09/22/98[3] - 09/23/98	ND	0.000790	ELD-228
		09/22/98[3] - 09/23/98	ND	0.000798	ELD-229
		09/23/98[3] - 09/24/98	ND	0.000781	ELD-242
		09/23/98[3] - 09/24/98	0.000770	0.000770	ELD-243
Sutters Mill Elementary School	Lotus	06/10/98 - 06/11/98	ND	0.000748	ELD-59
		06/11/98 - 06/12/98	ND	0.000735	ELD-60
		06/15/98 - 06/16/98	ND	0.000747	ELD-70
		09/08/98[3] - 09/09/98	ND	0.000936	ELD-189
		09/08/98[3] - 09/09/98	ND	0.000931	ELD-190
		09/09/98[3] - 09/10/98	ND	0.000951	ELD-197
		09/09/98[3] - 09/10/98	0.003664	0.000916	ELD-198
		09/10/98[3] - 09/11/98	0.000994	0.000994	ELD-205
		09/10/98[3] - 09/11/98	0.001015	0.001015	ELD-206

Box Blank[4]	04/23/98	ND	0.001727	ELD-16
	04/30/98	ND	0.001727	ELD-33
	06/03/98	ND	0.000729	ELD-53
	06/15/98	ND	0.000729	ELD-76
	06/18/98	ND	0.000971	ELD-93
	07/02/98	ND	0.000971	ELD-113
	07/08/98	ND	0.000971	ELD-142
	08/06/98	ND	0.000971	ELD-156
	08/27/98	0.00936	0.000936	ELD-182
	09/10/98	ND	0.000936	ELD-208
Field Blank[5]	04/23/98	ND	0.001727	ELD-17
	04/30/98	ND	0.001727	ELD-34
	06/03/98	ND	0.000729	ELD-54
	06/15/98	ND	0.000729	ELD-77
	06/18/98	ND	0.000729	ELD-94
	07/02/98	ND	0.000971	ELD-114
	07/08/98	ND	0.000971	ELD-143
	08/06/98	ND	0.000971	ELD-157
	08/27/98	ND	0.000936	ELD-183
	09/10/98	ND	0.000936	ELD-209
	09/23/98	ND	0.000784	ELD-252

NOTES:

1. Asbestos fiber analysis by Transmission Electron Microscopy (TEM) performed by EPA 40 CFR Part 763 Final Rule (AHERA).
2. ND stands for None Detected.
3. Site of co-located samplers.
4. Box Blank is where an unused cartridge is removed from the box of unused filters and sent to the lab for analysis.
5. A field blank is where an unused cartridge is attached to a sampling train and the flow rate is measured. The cartridge is then sealed and sent to the lab for analysis.
6. MDL means Minimum Detection Limit.

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Asbestos Air Monitoring

A department of the California Environmental Protection Agency

Table 2

Measured Ambient Asbestos Concentrations Near a Potential Asbestos Source in El Dorado County, California

This page updated January 15, 1999.

Detailed Listing

(Updated January 15, 1999)

Location Name	Geographical Area/City	Sampling Dates	Concentration (fibers per cc)		Sample Number
			Measured[2]	MDL[6]	
Private Parcel #1	Lotus	10/01 - 10/02/98	ND	0.00079	S1-1
		10/02 - 10/03/98	ND	0.00080	S1-5
		10/03 - 10/04/98	ND	0.000794	S1-9
		10/04 - 10/05/98	0.00316	0.00079	S1-13A
		10/06 - 10/07/98	0.00317	0.000794	S1-16
		10/07 - 10/08/98	0.00237	0.00079	S1-20
		10/08 - 10/09/98	0.0118	0.000791	S1-24
		10/09 - 10/10/98	0.0135	0.000797	S1-28
		10/10 - 10/11/98	0.000795	0.000795	S1-32
		10/11 - 10/12/98	0.00875	0.000795	S1-36
		10/12 - 10/13/98	0.00164	0.000825	S1-41
		10/13 - 10/14/98	0.145	0.00392	S1-44
		10/17 - 10/18/98	0.00235	0.000786	S1-49
		10/06 - 10/07/98	0.0103	0.000794	S1-16-R
		10/08 - 10/09/98	0.0118	0.000791	S1-24-R
Private Residence #1	Lotus	10/01 - 10/02/98	0.00154	0.000773	S2-1
		10/02 - 10/03/98	ND	0.00101	S2-4
		10/03 - 10/04/98	0.0102	0.000785	S2-5
		10/04 - 10/05/98	ND	0.000801	S2-7
		10/06 - 10/07/98	0.00563	0.000805	S2-8
		10/07 - 10/08/98	0.00631	0.000789	S2-10
		10/08 - 10/09/98	0.028	0.00112	S2-12
		10/09 - 10/10/98	0.0183	0.000872	S2-14
		10/10 - 10/11/98	0.0103	0.000793	S2-16

		10/11 - 10/12/98	0.00399	0.000798	S2-18
		10/12 - 10/13/98	0.012	0.000802	S2-20
		10/13 - 10/14/98	ND	0.00082	S2-22
		10/17 - 10/18/98	0.0288	0.0013	S2-24
		10/12 - 10/13/98	ND	0.000802	S2-20-R
Private Parcel #2	Lotus	10/01 - 10/02/98	ND	0.000775	S3-1
		10/02 - 10/03/98	0.0004	0.000811	S3-3
		10/03 - 10/04/98	0.00318	0.000795	S3-5
		10/04 - 10/05/98	0.00628	0.000786	S3-7
		10/06 - 10/07/98	0.00813	0.000813	S3-8
		10/07 - 10/08/98	0.000774	0.000774	S3-10
		10/08 - 10/09/98	0.00475	0.000792	S3-12
		10/09 - 10/10/98	0.00159	0.000799	S3-14
		10/10 - 10/11/98	0.004	0.000802	S3-16
		10/11 - 10/12/98	0.00386	0.000772	S3-18
		10/12 - 10/13/98	0.00237	0.000793	S3-20
		10/13 - 10/14/98	0.00802	0.000802	S3-22
		10/17 - 10/18/98	0.00472	0.000787	S3-24
Private Parcel #3	Lotus	10/01 - 10/02/98	0.000795	0.000795	S4-1
		10/02 - 10/03/98	0.00394	0.000789	S4-5
		10/03 - 10/04/98	0.0016	0.000804	S4-9
		10/04 - 10/05/98	ND	0.00079	S4-13
		10/06 - 10/07/98	0.00873	0.000794	S4-13
		10/07 - 10/08/98	0.00155	0.00078	S4-17
		10/08 - 10/09/98	ND	0.000777	S4-21
		10/09 - 10/10/98	ND	0.000837	S4-25
		10/10 - 10/11/98	0.0156	0.000785	S4-29
		10/11 - 10/12/98	0.00863	0.000785	S4-33
		10/12 - 10/13/98	ND	0.000809	S4-38
		10/13 - 10/14/98	0.0275	0.000918	S4-41
		10/17 - 10/18/98	0.00309	0.000774	S4-45
		10/11 - 10/12/98	0.00392	0.000785	S4-33-R
		10/13 - 10/14/98	0.00165	0.000826	S4-41-R
Private Residence #1	Greenstone Subdivision	10/01 - 10/02/98	0.0674	0.00157	S5-1
		10/02 - 10/03/98	0.00398	0.000797	S5-3
		10/03 - 10/04/98	0.00313	0.000785	S5-5
		10/04 - 10/05/98	0.00158	0.000791	S5-7
		10/06 - 10/07/98	0.00157	0.000789	S5-8
		10/07 - 10/08/98	ND	0.000758	S5-10
		10/08 - 10/09/98	0.0168	0.000845	S5-12

		10/09 - 10/10/98	0.00868	0.00079	S5-14
		10/10 - 10/11/98	ND	0.000789	S5-16
		10/11 - 10/12/98	0.00313	0.000785	S5-18
		10/12 - 10/13/98	ND	0.000823	S5-20
		10/13 - 10/14/98	ND	0.000815	S5-22
		10/17 - 10/18/98	ND	0.000785	S5-24
		10/01 - 10/02/98	0.000785	0.000785	S5-1-R
		10/08 - 10/09/98	0.0109	0.000845	S5-12-R
		10/09 - 10/10/98	0.00789	0.00079	S5-14-R
Private Residence #2	Greenstone Subdivision	10/01 - 10/02/98	0.0443	0.00164	S6-1
		10/02 - 10/03/98	0.000787	0.000787	S6-3
		10/03 - 10/04/98	ND	0.000794	S6-5
		10/04 - 10/05/98	ND	0.00079	S6-7
		10/06 - 10/07/98	ND	0.000802	S6-8
		10/07 - 10/08/98	ND	0.00078	S6-10
		10/08 - 10/09/98	0.00389	0.00078	S6-12
		10/09 - 10/10/98	0.00158	0.00079	S6-14
		10/10 - 10/11/98	0.00235	0.000785	S6-16
		10/11 - 10/12/98	*	0.0324	S6-18
		10/12 - 10/13/98	0.000822	0.000822	S6-20
		10/13 - 10/14/98	ND	0.000805	S6-22
		10/17 - 10/18/98	0.0047	0.000785	S6-25
		10/17 - 10/18/98	0.00706	0.000785	S6-25-R
Entrance to Quarry	Lotus	10/01 - 10/02/98	0.117	0.0042	S8-1
		10/02 - 10/03/98	ND	0.000793	S8-3
		10/03 - 10/04/98	0.0157	0.000789	S8-5
		10/04 - 10/05/98	*	0.0221	S8-7
		10/06 - 10/07/98	0.0884	0.00402	S8-8
		10/07 - 10/08/98	0.0298	0.00129	S8-10
		10/08 - 10/09/98	0.169	0.00395	S8-12
		10/09 - 10/10/98	0.0355	0.00131	S8-14
		10/10 - 10/11/98	0.00395	0.00079	S8-16
		10/11 - 10/12/98	0.0578	0.00262	S8-18
		10/12 - 10/13/98	0.00241	0.000805	S8-20
		10/13 - 10/14/98	0.008	0.000801	S8-22
		10/17 - 10/18/98	0.0131	0.000771	S8-25
		10/01 - 10/02/98	0.0209	0.000839	S8-1-R
		10/02 - 10/03/98	0.0325	0.000793	S8-3-R
		10/03 - 10/04/98	0.0141	0.000789	S8-5-R
		10/04 - 10/05/98	*	0.0221	S8-7-R
		10/06 - 10/07/98	0.0784	0.00201	S8-8-R

	10/07 - 10/08/98	0.0466	0.00155	S8-10-R
	10/08 - 10/09/98	0.154	0.00197	S8-12-R
	10/09 - 10/10/98	0.0616	0.00158	S8-14-R
	10/10 - 10/11/98	0.0325	0.000987	S8-16-R
	10/11 - 10/12/98	0.0305	0.000986	S8-18-R
	10/12 - 10/13/98	0.0402	0.00134	S8-20-R
	10/13 - 10/14/98	0.124	0.004	S8-22-R
	10/17 - 10/18/98	0.0110	0.00197	S8-25-R

* These samples did not conform to AHERA standards and were not included.

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A department of the California Environmental Protection Agency

Table 3

Measured Ambient Asbestos Concentrations Asbestos Monitoring in Silva Valley

This page updated September 15, 1999.

Detailed Listing

(Updated September 15, 1999)

Location Name	Geographical Area/City	Sampling Dates	Concentration (fibers per cc)		Sample Number
			Measured	MDL[1]	
Oak Ridge High School Site #1	El Dorado Hills	04/21/99 - 04/22/99	ND	0.0010	ORHS3-1
		04/22/99 - 04/23/99	ND	0.0010	ORHS3-2
		04/26/99 - 04/27/99	ND	0.0010	ORHS3-3
		04/27/99 -04/28/99	ND	0.0010	ORHS3-4
		04/28/99 - 04/29/99	ND	0.0010	ORHS3-5
Oak Ridge High School Site #2	El Dorado Hills	04/21/99 - 04/22/99	ND	0.0010	ORHS4-1
		04/22/99 - 04/23/99	ND	0.0010	ORHS4-2
		04/26/99 - 04/27/99	ND	0.0010	ORHS4-3
		04/27/99 -04/28/99	ND	0.0010	ORHS4-4
		04/28/99 - 04/29/99	ND	0.0010	ORHS4-5
Silva Elementary School Site #1	El Dorado Hills	04/21/99 - 04/22/99	0.0019	0.0010	SESN-1
		04/22/99 - 04/23/99	ND	0.0010	SESN-2
		04/26/99 - 04/27/99	ND	0.0010	SESN-3
		04/27/99 -04/28/99	ND	0.0010	SESN-4
		04/28/99 - 04/29/99	ND	0.0010	SESN-5
Silva Elementary School Site #2	El Dorado Hills	04/21/99 - 04/22/99	0.0010	0.0010	SESS-1
		04/22/99 - 04/23/99	ND	0.0010	SESS-2
		04/26/99 - 04/27/99	ND	0.0008	SESS-3
		04/27/99 -04/28/99	ND	0.0010	SESS-4
		04/28/99 - 04/29/99	ND	0.0010	SESS-5
Silva Elementary School Site #3	El Dorado Hills	04/22/99 - 04/23/99	0.0009	0.0009	SESNG-1
		04/23/99 - 04/24/99	ND	0.0010	SESNG-2

		04/26/99 - 04/27/99	ND	0.0008	SESNG-3
		04/27/99 -04/28/99	ND	0.0010	SESNG-4
		04/28/99 - 04/29/99	ND	0.0009	SESNG-5
Silva Elementary School Site #4	El Dorado Hills	04/22/99 - 04/23/99	0.0019	0.0010	SESSG-1
		04/23/99 - 04/24/99	ND	0.0010	SESSG-2
		04/26/99 - 04/27/99	0.0008	0.0008	SESSG-3
		04/27/99 -04/28/99	ND	0.0009	SESSG-4
		04/28/99 - 04/29/99	ND	0.0010	SESSG-5
Construction Site	El Dorado Hills	04/21/99 - 04/22/99	ND	0.0010	CONST-1
		04/22/99 - 04/23/99	ND	0.0010	CONST-2
		04/26/99 - 04/27/99	ND	0.0010	CONST-3
		04/27/99 -04/28/99	ND	0.0010	CONST-4
		04/28/99 - 04/29/99	ND	0.0010	CONST-5
Box Blank		4/29/99	ND	0.0010	BOX-1
Field Blank		4/29/99	ND	0.0010	FIELD-1

NOTES:

1. MDL - Minimum Detection Limit.
2. ND - no asbestos detected.

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California Air Resources Board

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Table 4
Measured Ambient Asbestos Concentrations Asbestos Monitoring in Garden Valley

This page updated December 10, 1999.

Detailed Listing
(Updated December 10, 1999)

Location Name	Geographical Area/City	Sampling Dates	Concentration (fibers per cc)		Sample Number
			Measured	MDL[1]	
Golden Sierra High School	Garden Valley	08/16/99	0.0211	0.0008	GS3-1
		08/17/99	0.0009	0.0009	GS3-2
		08/18/99	0.0072	0.0009	GS3-3
		08/19/99	0.0008	0.0008	GS3-4
Garden Valley Park	Garden Valley	08/16/99	ND	0.0008	GVP-1
		08/17/99	0.0036	0.0009	GVP-2
		08/18/99	0.0084	0.0009	GVP-3
		08/19/99	0.0049	0.0010	GVP-4
Garden Valley Site #1	Garden Valley	08/16 - 08/17/99	0.0021	0.0003	GVS1-1
		08/17 - 08/18/99	0.0021	0.0005	GVS1-2
		08/18 - 08/19/99	0.0025	0.0003	GVS1-3
		08/23 - 08/24/99	ND	0.0009	GVS1-5
		08/24 - 08/25/99	0.0019	0.0009	GVS1-6
		08/25 - 08/26/99	0.0019	0.0010	GVS1-7
Garden Valley Site #2	Garden Valley	08/16 - 08/17/99	0.0050	0.0004	GVS2-1
		08/17 - 08/18/99	0.0023	0.0004	GVS2-2
		08/18 - 08/19/99	0.0023	0.0003	GVS2-3
		08/23 - 08/24/99	0.0010	0.0010	GVS2-5
		08/24 - 08/25/99	ND	0.0010	GVS2-6
		08/25 - 08/26/99	0.0039	0.0010	GVS2-7
Garden Valley Site #3	Garden Valley	08/16 - 08/17/99	0.0021	0.0003	GVS3-1
		08/17 - 08/18/99	0.0021	0.0004	GVS3-2
		08/18 - 08/19/99	0.0025	0.0003	GVS3-3

		08/23 - 08/24/99	ND	0.0010	GVS3-5
		08/24 - 08/25/99	0.0048	0.0010	GVS3-6
		08/25 - 08/26/99	0.0039	0.0010	GVS3-7
Garden Valley Site #4	Garden Valley	08/16 - 08/17/99	0.0032	0.0004	GVS4-1
		08/17 - 08/18/99	0.0045	0.0003	GVS4-2
		08/18 - 08/19/99	0.0024	0.0003	GVS4-3
		08/23 - 08/24/99	0.0010	0.0010	GVS4-5
		08/24 - 08/25/99	0.0010	0.0010	GVS4-6
		08/25 - 08/26/99	0.0029	0.0010	GVS4-7
Garden Valley Site #5	Garden Valley	08/16 - 08/17/99	0.0038	0.0003	GVS5-1
		08/17 - 08/18/99	0.0041	0.0004	GVS5-2
		08/18 - 08/19/99	0.0027	0.0003	GVS5-3
		08/23 - 08/24/99	ND	0.0010	GVS5-5
		08/24 - 08/24/99	ND	0.0030	GVS5-6
		08/25 - 08/26/99	0.0029	0.0010	GVS5-7

NOTES:

1. MDL - Minimum Detection Limit.
2. ND - no asbestos detected.

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Table 5

Measured Ambient Asbestos Concentrations Asbestos Monitoring Around Woedee Drive

This page updated May 12, 2000.

Detailed Listing

(Updated May 12, 2000)

Location Name	Geographical Area/City	Sampling Dates	Concentration (fibers per cc)		Sample Number
			Measured	MDL[1]	
Vacant Lot	Woedee Drive	01/07/00	ND	0.0008	PILE-1
		01/08/00	ND	0.0011	PILE-2
		01/08/00	ND	0.0007	PILE-3
		01/09/00	ND	0.0010	PILE-4
		01/09/00	ND	0.0007	PILE-5
		01/10/00	ND	0.0010	PILE-6
Construction Site	Woedee Drive	01/08/00	ND	0.0010	CONST-2
		01/08/00	ND	0.0007	CONST-3
		01/09/00	ND	0.0009	CONST-4
		01/09/00	ND	0.0006	CONST-5
		01/10/00	ND	0.0010	CONST-6
Community Center Pool	Woedee Drive	01/07/00	ND	0.0005	POOL-1
		01/08/00	ND	0.0009	POOL-2
		01/09/00	ND	0.0010	POOL-4
		01/09/00	ND	0.0007	POOL-5
		01/10/00	ND	0.0010	POOL-6
Bass Lake	Woedee Drive	01/07/00	ND	0.0007	LAKE-1
		01/08/00	ND	0.0008	LAKE-2
		01/08/00	ND	0.0008	LAKE-3
		01/09/00	ND	0.0010	LAKE-4
		01/09/00	ND	0.0008	LAKE-5
		01/10/00	ND	0.0010	LAKE-6

NOTES:

1. MDL - Minimum Detection Limit.
2. ND - no asbestos detected.

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Table 6

Measured Ambient Asbestos Concentrations Asbestos Monitoring During Pile Removal Project

This page updated May 12, 2000.

Detailed Listing

(Updated May 12, 2000)

Location Name	Geographical Area/City	Sampling Dates	Concentration (fibers per cc)		Sample Number
			Measured	MDL[1]	
East	Woedee Drive	02/08/00	ND	0.0007	WDYEAST1-1
		02/09/00	ND	0.0009	WDYEAST2-5
North	Woedee Drive	02/08/00	ND	0.0007	WEYNOR1-2
		02/09/00	ND	0.0009	WEYNOR2-6
South	Woedee Drive	02/08/00	ND	0.0008	WDYSOU1-3
		02/09/00	ND	0.0008	WDYSOU2-7
West	Woedee Drive	02/08/00	ND	0.0008	WDYWES1-4
		02/09/00	ND	0.0008	WDYWES2-8

NOTES:

1. MDL - Minimum Detection Limit.
2. ND - no asbestos detected.

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A department of the California Environmental Protection Agency

Appendix E

Asbestos Monitoring Reports Near Unpaved Roads

Appendix E-1-A

Air Resources Board
Quarry Entrance - Intersection of Unpaved/Paved Road

Air Resources Board

Alan C. Lloyd, Ph.D.
Chairman
2020 L Street • P.O. Box 2815 • Sacramento, California 95812 • www.arb.ca.gov

Winston H. Hickox
Secretary for Environmental Protection

Gray Davis
Governor

MEMORANDUM

TO: Stephanie Trenck, Chief
Program Assessment and Data Management Branch
Compliance Division

FROM: George Lew, Chief
Engineering and Laboratory Branch
Monitoring and Laboratory Division

DATE: June 25, 1999

SUBJECT: RESULTS OF WEBER CREEK QUARRY AIRBORNE ASBESTOS MONITORING RESULTS THROUGH MAY 1999.

I have enclosed the results (Attachment I) of all sampling performed at Weber Creek Quarry (Quarry) through May 1999. Five sampling sites were chosen around the Quarry. The number of sampling sites was reduced to only Site 8 for all sampling performed on and after the May 26,1999. Site 8 is at the entrance of the quarry. A map of the sampling locations is contained in Attachment II. Sampling is performed on a twelve day cycle. The calendar in Attachment III shows the days samples were taken. A 24-hour sampler and a meteorological station were set up at each site. RJ Lee Group, our contract laboratory, sends us a report for each sampling day's samples. These reports are contained in Attachment IV.

The results from the monitoring through May 1999 have been tabulated with the same format used by RJ Lee. RJ Lee reports the results in four decimal places which results. The number of significant figures varies from one to three.

Samplers were set up on approximately the five compass points. A site was chosen on the North, East, South and West of the Quarry. These sites were also used in the October 1998 monitoring program. The site numbering scheme used for the October 1998 monitoring program was also used in this maintenance program. Site one was the southern most sampler. Site two was the northern most sampler. Site six was the eastern most sampler. Site eight was at the entrance of the quarry and the western most sampler. An additional site (site 9) was chosen as a background location.

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Sampling occurred on a 12 day cycle, starting on January 14, 1999. If rain was falling at the time of deployment of the samplers, sampling did not occur on that day. Sampling started again on the next 12th day. Only February 12, 1999 sampling was canceled due to rain. Chain of Custody was kept on all samples. MLD staff sent the collected samples with the Chain of Custody forms to the contract lab (RJ Lee) by over night express mail (UPS).

I have also attached the asbestos analysis reports (Attachment IV) from the contract lab (RJ Lee). There is a report for each sampling day. RJ Lee supplies MLD with three tables and a computer generated count-sheet for each sample. They call the first table "Test Report." This table contains the data used to compile and produce the reports you have seen from MLD in the past. We titled RJ Lee's second table "Table II." The table has the asbestos concentrations for fibers $\geq$ 5 microns in length. The final table from RJ Lee contains the uncertainty data for each sample. The RJ Lee count-sheets are computer generated copies of the count-sheets produced during analysis.

If you have questions or comments or need further information, please contact me at 263-1630 or have your staff contact Michael Spears, Manager for the Evaluation Section or James McCormack of his staff at 263-2060.

Attachments (4)

cc: Bill Loscutoff

Attachment I

Measured Ambient Asbestos Concentrations
Monitoring Around Weber Creek Quarry

(January 14, 1999)

Log Number	Sample Id	Site Number	Sampling Dates	Concentration (fibers per CC) MDL	Measured all fibers	Measured > 5um
WCQ-500	S9-500	Site 9	01/14 - 01/15/99	0.0010	ND	ND
WCQ-501	S9-501	Site 9	01/14 - 01/15/99	0.0010	0.0019	ND
WCQ-502	S6-502	Site 6	01/14 - 01/15/99	0.0010	0.0010	ND
WCQ-503	S6-503	Site 6	01/14 - 01/15/99	0.0010	ND	ND
WCQ-504	S8-504	Site 8	01/14 - 01/15/99	0.0012	0.0363	0.0012
WCQ-505	S8-505	Site 8	01/14 - 01/15/99	0.0019	0.0620	0.0019

(January 26 , 1999)

Log Number	Sample Id	Site Number	Sampling Dates	Concentration (fibers per CC) MDL	Measured all fibers	Measured > 5um
WCQ-506	S9-506	Site 9	03/15 - 03/16/99	0.0010	ND	ND
WCQ-507	S6-507	Site 6	03/15 - 03/16/99	0.0010	ND	ND
WCQ-508	S1-508	Site 1	03/15 - 03/16/99	0.0010	ND	ND
WCQ-509	S8-509	Site 8	03/15 - 03/16/99	0.0010	0.0242	0.0010
WCQ-510	S2-510	Site 2	03/15 - 03/16/99	0.0010	ND	ND

Notes:

MDL: Acronym for Minimum Detection Limit
ND: Acronym for non-detect
Concentration Format: same as reported by RJ Lee.

Attachment I Cont'd

Measured Ambient Asbestos Concentrations
Monitoring Around Weber Creek Quarry

(March 3, 1999)

Log Number	Sample Id	Site Number	Sampling Dates	Concentration (fibers per CC) MDL	Measured all fibers	Measured > 5um
WCQ-520	S9-520	Site 9	03/03 - 03/04/99	0.0010	ND	ND
WCQ-521	S6-521	Site 6	03/03 - 03/04/99	0.0017	ND	ND
WCQ-522	S1-522	Site 1	03/03 - 03/04/99	0.0010	ND	ND
WCQ-523	S8-523	Site 8	03/03 - 03/04/99	0.0010	0.0019	ND
WCQ-524	S2-524	Site 2	03/03 - 03/04/99	0.0010	ND	ND
WCQ-525	LI-525	field blank	03/04/99	0.0010	ND	ND
WCQ-526	NI-526	box blank	03/04/99	0.0010	ND	ND

(March 15, 1999)

Log Number	Sample Id	Site Number	Sampling Dates	Concentration (fibers per CC) MDL	Measured all fibers	Measured > 5um
WCQ-527	S9-527	Site 9	03/15 - 03/16/99	0.0015	ND	ND
WCQ-528	S6-528	Site 6	03/15 - 03/16/99	0.0010	ND	ND
WCQ-529	S1-529	Site 1	03/15 - 03/16/99	0.0010	ND	ND
WCQ-530	S8-530	Site 8	03/15 - 03/16/99	0.0010	0.0263	0.0029
WCQ-531	S2-531	Site 2	03/15 - 03/16/99	0.0010	0.0010	ND
WCQ-532	LI-532	field blank	03/15/99	0.0010	ND	ND
WCQ-533	NI-533	box blank	03/15/99	0.0010	ND	ND

Notes:

MDL: Acronym for Minimum Detection Limit
ND: Acronym for non-detect
Concentration Format: same as reported by RJ Lee.

Attachment I Cont'd

Measured Ambient Asbestos Concentrations
Monitoring Around Weber Creek Quarry

(March 27, 1999)

Log Number	Sample Id	Site Number	Sampling Dates	Concentration (fibers per CC)		
				MDL	Measured	
					all fibers	> 5um
WCQ-534	S9-534	Site 9	03/27 - 03/28/99	0.0010	ND	ND
WCQ-535	S6-535	Site 6	03/27 - 03/28/99	0.0010	ND	ND
WCQ-536	S1-536	Site 1	03/27 - 03/28/99	0.0010	ND	ND
WCQ-537	S8-537	Site 8	03/27 - 03/28/99	0.0010	ND	ND
WCQ-538	S2-538	Site 2	03/27 - 03/28/99	0.0010	ND	ND
WCQ-539	LI-539	field blank	03/28/99	0.0010	ND	ND
WCQ-540	NI-540	box blank	03/28/99	0.0010	ND	ND

(April 8, 1999)

Log Number	Sample Id	Site Number	Sampling Dates	Concentration (fibers per CC)		
				MDL	Measured	
					all fibers	> 5um
WCQ-541	S9-541	Site 9	04/08 - 04/09/99	0.0010	ND	ND
WCQ-542	S6-542	Site 6	04/08 - 04/09/99	0.0015	ND	ND
WCQ-543	S1-543	Site 1	04/08 - 04/09/99	0.0010	ND	ND
WCQ-544	S8-544	Site 8	04/08 - 04/09/99	0.0010	0.0078	0.0010
WCQ-545	S2-545	Site 2	04/08 - 04/09/99	0.0058	ND	ND
WCQ-546	LI-546	field blank	04/09/99	0.0010	ND	ND
WCQ-547	NI-547	box blank	04/09/99	0.0010	ND	ND

Notes:
MDL: Acronym for Minimum Detection Limit
ND: Acronym for non-detect
Concentration Format: same as reported by RJ Lee.

Attachment I Cont'd

Measured Ambient Asbestos Concentrations
Monitoring Around Weber Creek Quarry

(April 20, 1999)

				Concentration (fibers per CC)		
Log Number	Sample Id	Site Number	Sampling Dates	MDL	Measured	
					all fibers	> 5um
WCQ-548	S9-548	Site 9	04/20 - 04/21/99	0.0010	0.0019	0.0010
WCQ-549	S6-549	Site 6	04/20 - 04/21/99	0.0014	0.0014	ND
WCQ-550	S1-550	Site 1	04/20 - 04/21/99	0.0075	ND	ND
WCQ-551	S8-551	Site 8	04/20 - 04/21/99	0.0010	0.0155	0.0010
WCQ-552	S2-552	Site 2	04/20 - 04/21/99	0.0010	0.0029	ND
WCQ-553	LI-553	field blank	04/21/99	0.0010	ND	ND
WCQ-554	NI-554	box blank	04/21/99	0.0010	ND	ND

(May 2, 1999)

				Concentration (fibers per CC)		
Log Number	Sample Id	Site Number	Sampling Dates	MDL	Measured	
					all fibers	> 5um
WCQ-555	S9-555	Site 9	05/02 - 05/03/99	0.0010	ND	ND
WCQ-556	S6-556	Site 6	05/02 - 05/03/99	0.0010	0.0010	ND
WCQ-557	S1-557	Site 1	05/02 - 05/03/99	0.0010	0.0019	ND
WCQ-558	S8-558	Site 8	05/02 - 05/03/99	0.0010	0.0134	ND
WCQ-559	S2-559	Site 2	05/02 - 05/03/99	0.0010	0.0010	ND
WCQ-560	LI-560	field blank	05/03/99	0.0010	ND	ND
WCQ-561	NI-561	box blank	05/03/99	0.0010	ND	ND

Notes:

MDL: Acronym for Minimum Detection Limit
ND: Acronym for non-detect
Concentration Format: same as reported by RJ Lee.

Attachment I Cont'd

Measured Ambient Asbestos Concentrations
Monitoring Around Weber Creek Quarry

(May 14, 1999)

Log Number	Sample Id	Site Number	Sampling Dates	Concentration (fibers per CC)		
				MDL	Measured	
					all fibers	> 5um
WCQ-562	S9-562	Site 9	05/14 - 05/15/99	0.0010	ND	ND
WCQ-563	S6-563	Site 6	05/14 - 05/15/99	0.0010	ND	ND
WCQ-564	S1-564	Site 1	05/14 - 05/15/99	0.0010	0.0019	ND
WCQ-565	S8-565	Site 8	05/14 - 05/15/99	0.0010	0.0126	ND
WCQ-566	S2-566	Site 2	05/14 - 05/15/99	0.0010	0.0067	ND
WCQ-567	LI-567	field blank	05/15/99	0.0010	ND	ND
WCQ-568	NI-568	box blank	05/15/99	0.0010	ND	ND

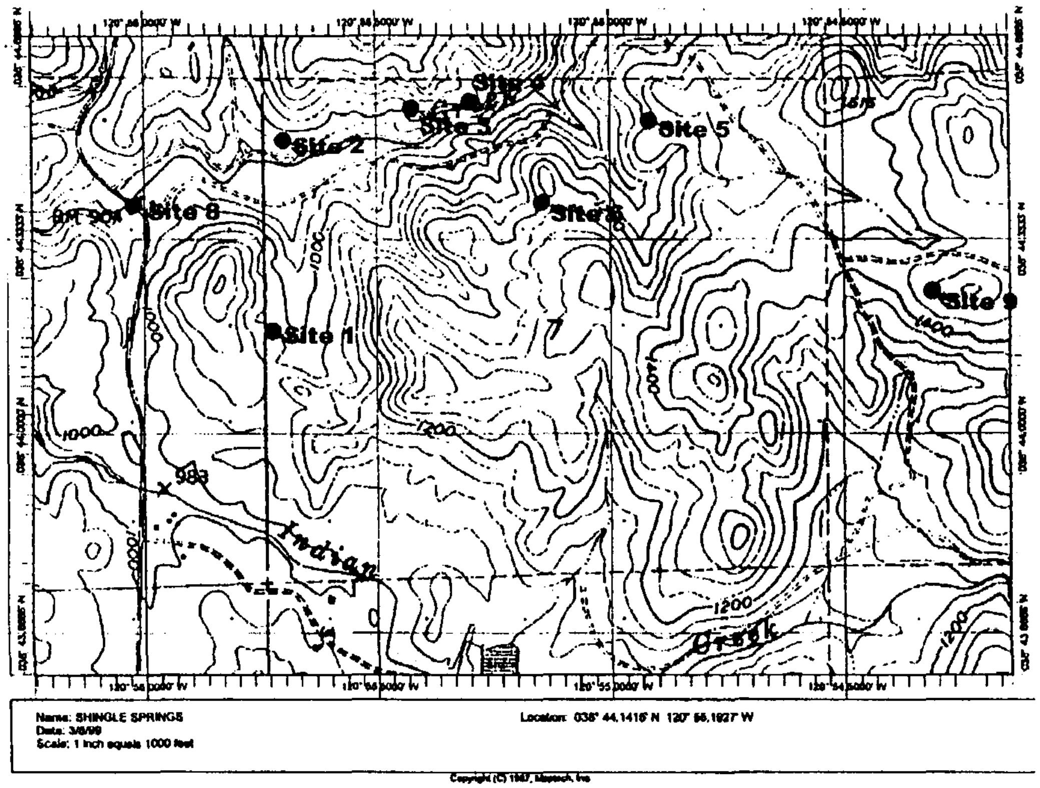
(May 26, 1999)

Log Number	Sample Id	Site Number	Sampling Dates	Concentration (fibers per CC)		
				MDL	Measured	
					all fibers	> 5um
WCQ-569	S8-569	Site 8	05/26 - 05/27/99	0.0014	0.0252	0.0010
WCQ-570	LI-570	field blank	05/27/99	0.0010	ND	ND
WCQ-571	NI-571	box blank	05/27/99	0.0010	ND	ND

Notes:

MDL: Acronym for Minimum Detection Limit
ND: Acronym for non-detect
Concentration Format: same as reported by RJ Lee.

Attachment II
Map of Sampling Locations



Attachment III

MAINTENANCE MONITORING AT WEBER CREEK QUARRY

SCHEDULE OF SAMPLING DATES THROUGH JUNE 30,1999

OCTOBER 1998

SUN	MON	TUE	WED	THU	FRI	SAT
				1 S	2 S	3 S
4 S	5 S	6 S	7 S	8 S	9 S	10 S
11 S	12 S	13 S	14	15	16	17 S
18 S	19	20	21	22	23	24
25	26	27	28	29	30	31

NOVEMBER 1998

SUN	MON	TUE	WED	THU	FRI	SAT
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30					

DECEMBER 1998

SUN	MON	TUE	WED	THU	FRI	SAT
		1	2	3	4	5
6	7	8	9	10	11	12
13	14	15	16	17	18	19
20	21	22	23	24	25	26
27	28	29	30	31		

JANUARY 1999

SUN	MON	TUE	WED	THU	FRI	SAT
					1	2
3	4	5	6	7	8	9
10	11	12	13	14 M	15	16
17	18	19	20	21	22	23
24/31	25	26 M	27	28	29	30

FEBRUARY 1999

SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3	4	5	6
7	8 R	9	10	11	12	13
14	15	16	17	18	19	20 M
21	22	23	24	25	26	27
28						

MARCH 1999

SUN	MON	TUE	WED	THU	FRI	SAT
	1	2	3 M	4	5	6
7	8	9	10	11	12	13
14	15 M	16	17	18	19	20
21	22	23	24	25	26	27 M
28	29	30	31			

APRIL 1999

SUN	MON	TUE	WED	THU	FRI	SAT
				1	2	3
4	5	6	7	8 M	9	10
11	12	13	14	15	16	17
18	19	20 M	21	22	23	24
25	26	27	28	29	30	

MAY 1999

SUN	MON	TUE	WED	THU	FRI	SAT
						1
2 M	3	4	5	6	7	8
9	10	11	12	13	14 M	15
16	17	18	19	20	21	22
23/30	24/31	25	26 M	27	28	29

JUNE 1999

SUN	MON	TUE	WED	THU	FRI	SAT
		1	2	3	4	5
6	7 (M)	8	9	10	11	12
11	12	13	14	15	16	17
18	19 (M)	20	21	22	25	26
27	28	29	30			

S	identifies days sampling occurred for full blown monitoring program..
M	identifies days sampling occurred for maintenance monitoring program.
R	identifies days sampling did not occur for maintenance monitoring program due to rain.
(M)	identifies future days sampling is scheduled to occur for maintenance monitoring program.

Attachment IV
RJ Lee Group Reports

Appendix E-1-B

Air Resources Board
Bulk Sampling at Quarry Entrance

Air Resources Board

Winston H. Hickox
Secretary for Environmental Protection

Alan C. Lloyd, Ph.D.
Chairman
2020 L Street • P.O. Box 2815 • Sacramento, California 95812 • www.arb.ca.gov

Gray Davis
Governor

MEMORANDUM

TO: Todd Wong, Manager
Emissions Evaluation Section
Stationary Source Division

FROM: George Lew, Chief George Lew
Engineering and Laboratory Branch
Monitoring and Laboratory Division

DATE: September 14, 1999

SUBJECT: RESULTS OF BULK SAMPLING AT WEBER CREEK QUARRY ENTRANCE AND WILD TURKEY DRIVE QUARRY

This memorandum transmits the results for bulk samples taken at the Weber Creek Quarry (WCQ) and at the quarry on Wild Turkey Drive (WTDQ). These samples were collected by ARB staff and analyzed by RJ Lee using ARB Test Method 435 (TM435).

In May 1999 ARB staff collected four bulk samples at the entrance to WCQ following the requirements set out in TM435. All four samples had a chrysotile asbestos concentration of less than 1%, (See Attachment 1). Two of the samples had a concentration of 0.25%. No asbestos was found on one sample. The fourth sample had 0.75%. Minimum detection limit of TM435 is 0.25% asbestos. Attachment 2 contains RJ Lee's report.

Staff took three bulk samples at WTDQ. You informed us that this quarry had a deposit of tremolite asbestos. We did not collect representative samples as required by TM435 but rather collected samples that are suspected to be tremolite, the purpose is to verify the presence of tremolite asbestos. Ron Churchill, a registered Geologist from the Department of Conservation's Division of Mines and Geology accompanied ARB staff to the quarry to identify the tremolite veins. Staff took samples at three different veins within the quarry. The asbestos concentrations for the three samples were 90.75%, 28.5%, and 83%, (See Attachment 1). RJ Lee reported (Attachment 2) each sample contained tremolite.

If you have questions or need further information, please contact me at 327-0900.

Attachments (3)

cc: Bill Loscutoff

Attachment 1
Results of ARB Test Method 435 Analysis

Log #	Sample #	Description	Asbestos Concentration	Asbestiform
Wild Turkey Drive				
1	WTDQ-1	Vein on South side of quarry	90.75%	Tremolite
2	WTDQ-2	Vein on West side of quarry	28.5%	Tremolite
3	WTDQ-3	Vein on North side of quarry	83%	Tremolite
Weber Creek Quarry				
WCQB-9991	1	Ten random grab samples	0.25%	Chrysotile
WCQB-9992	2	Ten random grab samples	0.75%	Chrysotile
WCQB-9993	3	Ten random grab samples	0.25%	Chrysotile
WCQB-9994	4	Ten random grab samples	ND	

ND means non-detected
Minimum detection Limit is 0.25%

Attachment 2
RJ Lee Report for Weber Creek Quarry

RJ Lee*Group,* Inc.

530 McCormick Street San Leandro, CA 94577
(510) 567-0480 • Fax (510) 567-0488

Fax Transmittal

TO: James E. McCormick

Company: California Air Resources Board

FAX: (916)263-2067

From: Scosha Brewer

Date: Thursday, April 29, 1999

RE: ~~C-99-031~~
AOC904222-PC
~~C-99-031~~ C-99-089

Total Number of Pages Being Transmitted (including cover page): 4

MESSAGE:

Analysis Requested: PLM NESHAPS-40

Number of Samples Received: 4

Number of Samples Analyzed: 4

Comments:

RJ Lee*Group*, Inc.

530 McCormick Street • San Leandro, CA 94577
510/567-0480 • FAX 510/567-0488

April 29, 1999

Mr. James E. McCormick
California Air Resources Board
P.O. Box 2815
2020 L Street
Sacramento, CA 95812

RE: PLM Point Count Asbestos Results for Samples as Shown on Table I
RJLee*Group*, Inc. Job No.: AOC904222-PC
Client P.O./Job Number: N/A
Client Job Name/Location: ~~C-99-03~~1 C-99-089

Dear Mr. McCormick:

Enclosed are the results from the polarized light microscopy (PLM) asbestos analysis of the above referenced samples. Samples were analyzed in accordance with guidelines set forth in the State of California, Air Resources Board (ARB), Test Method 435, Determination of Asbestos Content of Serpentine Aggregate (06/06/91).

Table I lists each sample identification number, gross sample description, type(s) and concentration of asbestos, type(s) and concentration of nonasbestos fibers, major components and concentration of nonfibrous material (NFM), sample run date, analyst, and the number of asbestos points counted in 400 total points. Asbestos concentrations are given in percents to the nearest 0.25%.

The ARB Method 435, Section 8.3 lists two exceptions to the point count rule. Exception I states: "If the sample is suspected of containing no asbestos a visual technique can be used to report that the sample does not contain asbestos". If the sample is point counted, and asbestos is observed but not counted, the sample will be reported as containing < 0.25% asbestos. Exception II states: "If the sample is suspected to have an asbestos content in excess of ten percent, a visual technique can be used to report that the sample contains greater than ten percent asbestos." In the case of Exception II, the visual technique allowed in the National Institute of Standards and Technology's (NIST) National Voluntary Laboratory Accreditation Program (NVLAP), Bulk Asbestos Handbook (NIST publication number NISTIR 88-3879, 10/88) will be followed. If either exception is used it will be noted under the Asb/Points category of Table I.

RJ Lee Group, Inc. is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) (NVLAP Participant Number 1208-2) for bulk asbestos fiber analysis (PLM), and by the California Department of Health Services, Environmental Laboratory Accreditation Program (CALELAP) for bulk asbestos analysis. Neither the NVLAP Accreditation of this laboratory nor this report may be used to claim product endorsement by NVLAP or any agency of the U.S.

These results are submitted pursuant to RJ Lee Group's current terms and conditions of sale, including the company's standard warranty and limitation of liability provisions and no responsibility or liability is assumed for the manner in which the results are used or interpreted. Unless notified in writing to return the samples covered by this report, RJ Lee Group will store the samples for a period of ninety (90) days before discarding. A shipping and handling fee will be assessed for the return of any samples.

Sincerely,

Stephen S. Yata
Geologist

SSY/sjb

Test Report - California Air Resources Board

Polarized Light, Point Count Analysis ARB Method 435

Project AOC904222-PC

		Asbestos						Nonasbestos						
Sample Number	Client Sample Number	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite	Cellulose	Mineral Wool	Fibrous Glass	Synthetic Fibers	Other Fibers	NonFibrous Material	Run Date Analyst
1687512CPL	WCQB-9991-1	0.25 %	-	-	-	-	-	-	-	-	-	-	99.75 %	4/29/99
Grey soil					*NFM:*	, Misc. Part.								SSY
													Asb/Points	0/400
1687513CPL	WCQB-9992-2	0.75 %	-	-	-	-	-	-	-	-	-	-	99.25 %	4/29/99
Grey soil					*NFM:*	, Misc. Part.								SSY
													Asb/Points	3/400
1687514CPL	WCQB-9993-3	0.25 %	-	-	-	-	-	-	-	-	-	-	99.75 %	4/29/99
Grey soil					*NFM:*	, Misc. Part.								SSY
													Asb/Points	1/400
1687515CPL	WCQB-9994-4	<0.25 %	-	-	-	-	-	-	-	-	-	-	99+ %	4/29/99
Grey soil					*NFM:*	, Misc. Part.								SSY
Layer Content:	<0.25% Chrysotile (seen But Not Counted)												**Asb/Points**	0/400

Samples received on: Friday, April 16, 1999

Authorized Signature

Stephen S. Yata, Geologist

Date Thursday, April 29, 1999

RJ Lee Group, Inc.
Bay Area Lab

530 McCormick Street
San Leandro, CA 94577

Phone (510) 567-0480
Fax (510) 567-0488

ACC904222-PC

CHAIN OF CUSTODY SAMPLE RECORD

Project #: C-99-031

Submitter: James E. McCormack

Log #	Sample I.D.	comments
WC9B - 9991	#1	4 GRABS COMPOSITED TO 1 SAMPLE
WC9B - 9992	#2	4 GRABS " " " "
WC9B - 9993	#3	4 GRABS " " " "
WC9B - 9994	#4	4 GRABS " " " "

WAS THE CHAIN OF CUSTODY SEAL INTACT ON SAMPLE CONTAINER?

ARB		RJ Lee Laboratory	
yes	James E McCormack	✓	D. Mu 4/16/99
(Yes/No)	Signature/Date	(Yes/No)	Signature/Date

CHAIN OF CUSTODY

ACTION	given by and date/time	taken by and date/time
XFER	James E McCormack MAC 4/15/99 1300	UPS 4/15/99
XFER	UPS 4/16/99	
Rec'd	D. Mu 4/16/99 @ 12:00	

Attachment 3
RJ Lee Report for Wild Turkey Drive Quarry

RJ Lee*Group*, Inc.

530 McCormick Street • San Leandro, CA 94577
510/567-0480 • FAX 510/567-0488

July 16, 1999

Mr. James McCormick
California Air Resources Board
Engineering & Laboratory Branch
600 North Market Blvd
Sacramento, CA 95834

RE: PLM Point Count Asbestos Results for Samples as Shown on Table I
RJLee*Group*, Inc. Job No.: AOC907077-PC
Client P.O./Job Number: C-~~99-03~~1 C-99-087
Client Job Name/Location: ~~C-99-031~~

Dear Mr. McCormick:

Enclosed are the results from the polarized light microscopy (PLM) asbestos analysis of the above referenced samples. Samples were analyzed in accordance with guidelines set forth in the State of California, Air Resources Board (ARB), Test Method 435, Determination of Asbestos Content of Serpentine Aggregate (06/06/91).

Table I lists each sample identification number, gross sample description, type(s) and concentration of asbestos, type(s) and concentration of nonasbestos fibers, major components and concentration of nonfibrous material (NFM), sample run date, analyst, and the number of asbestos points counted in 400 total points. Asbestos concentrations are given in percents to the nearest 0.25%.

The ARB Method 435, Section 8.3 lists two exceptions to the point count rule. Exception I states: "If the sample is suspected of containing no asbestos a visual technique can be used to report that the sample does not contain asbestos". If the sample is point counted, and asbestos is observed but not counted, the sample will be reported as containing < 0.25% asbestos. Exception II states: "If the sample is suspected to have an asbestos content in excess of ten percent, a visual technique can be used to report that the sample contains greater than ten percent asbestos." In the case of Exception II, the visual technique allowed in the National Institute of Standards and Technology's (NIST) National Voluntary Laboratory Accreditation Program (NVLAP), Bulk Asbestos Handbook (NIST publication number NISTIR 88-3879, 10/88) will be followed. If either exception is used it will be noted under the Asb/Points category of Table I.

RJ Lee Group, Inc. is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) (NVLAP Participant Number 1208-2) for bulk asbestos fiber analysis (PLM), and by the California Department of Health Services, Environmental Laboratory Accreditation Program (CALELAP) for bulk asbestos analysis. Neither the NVLAP Accreditation of this laboratory nor this report may be used to claim product endorsement by NVLAP or any agency of the U.S.

These results are submitted pursuant to RJ Lee Group's current terms and conditions of sale, including the company's standard warranty and limitation of liability provisions and no responsibility or liability is assumed for the manner in which the results are used or interpreted. Unless notified in writing to return the samples covered by this report, RJ Lee Group will store the samples for a period of ninety (90) days before discarding. A shipping and handling fee will be assessed for the return of any samples.

Sincerely,

Scott Stotler
Geologist

E-1-B-9

SS/sjb

Monroeville, PA • San Leandro, CA • Washington, DC • Houston, TX • Richland, WA

Test Report - California Air Resources Board

Polarized Light, Point Count Analysis Results

Project AOC907077-PC

Sample Number	Client Sample Number	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite	Cellulose	Mineral Wool	Fibrous Glass	Synthetic Fibers	Other Fibers	NonFibrous Material	Run Date Analyst
		Asbestos						Nonasbestos						
1692910CPL	1-WTDQ-1	-	-	-	-	90.75 %	-	-	-	-	-	-	9.25 %	7/14/99
Grey powder					*NFM:*	, Misc. Part.								SS
													Asb/Points	363/400
1692911CPL	2-WTDQ-2	-	-	-	-	28.5 %	-	-	-	-	-	-	71.5 %	7/14/99
White powder					*NFM:*	, Misc. Part.								SS
													Asb/Points	114/400
1692912CPL	3-WTDQ-3	-	-	-	-	83 %	-	-	-	-	-	-	17 %	7/14/99
White powder					*NFM:*	, Misc. Part.								SS
													Asb/Points	332/400

E-1-B-10

Samples received on: Tuesday, July 6, 1999

Authorized Signature
Scott Stotler, Geologist
Date Thursday, July 15, 1999

RJ Lee Group, Inc.
Bay Area Lab

530 McCormick Street
San Leandro, CA 94577

Phone (510) 567-0480
Fax (510) 567-0488

CHAIN OF CUSTODY SAMPLE RECORD

Project #: C-99-031

Submitted by: James E. McCormack

Log #	Sample I.D.	comments
1	WTDQ-1	CONE
2	WTDQ-2	CHEMX
3	WTDQ-3	AMERICAN

WAS THE CHAIN OF CUSTODY SEAL INTACT ON SAMPLE CONTAINER?

ARB		RJ Lee Laboratory	
Yes	James E McCormack 7/2/99		
(Yes/No)	Signature/Date	(Yes/No)	Signature/Date

CHAIN OF CUSTODY

ACTION	given by and date/time	taken by and date/time
XFER	James E McCormack 7/2/99	UPS 7/2/99
XFER	UPS	C.SPAIN@RJLEEGRO CSpain @ 7/6/99

[redacted]

Appendix E-2-A

Air Resources Board
Pothole Road Study

Air Resources Board

Alan C. Lloyd, Ph.D.
Chairman
2020 L Street • P.O. Box 2815 • Sacramento, California 95812 • www.arb.ca.gov

Winston H. Hickox
Secretary for Environmental Protection

Gray Davis
Governor

MEMORANDUM

TO: Todd Wong, Manager
Emissions Evaluation Section
Stationary Source Division

FROM: George Lew, Chief
Engineering and Laboratory Branch
Monitoring and Laboratory Division

DATE: September 4, 1999

SUBJECT: RESULTS OF AIRBORNE ASBESTOS MONITORING NEAR POTHOLES ON McKEON PONDEROSA WAY IN FORESTHILL CALIFORNIA

At the request of the Placer County APCD, Monitoring and Laboratory Division staff (staff) conducted airborne asbestos monitoring along the abandoned portion of McKeon Ponderosa Way (Road) in Foresthill, California. The monitoring goal is to determine if the dust, caused by vehicles going over the potholes, is a source of airborne asbestos. This Road is paved, is not maintained by the county due to its abandoned status, and has numerous potholes. These potholes expose the serpentine road base materials which have an asbestos content between 10 percent and over 50 percent according to a recent report by the Department of Toxic Substances Control. Staff observed that local traffic driving across the potholes, as well as nearby serpentine covered driveways, generated massive dust clouds. For this study driveways were not evaluated as a source of airborne asbestos.

A. AIRBORNE ASBESTOS MONITORING

1. Sampling

Staff conducted the airborne asbestos monitoring from July 5 through July 8, 1999. Three sampling sites were chosen along the Road. The sites were chosen due to their proximity to potholes in the Road, their distance from driveways, and the availability of a surface to setup the samplers. The first site, called "BEG" was 0.1 miles from the beginning of the Road. The second site, called "MID," was 1.2 miles from the "BEG" site. The third site, called "END" was

1.5 miles from the BEG site and at the entrance to an abandoned quarry. Attachment 1 is a street map showing the locations of the sampling sites. Aerial photographs from United States Geological Survey (USGS) are contained in Attachment 2 showing the sampling sites. A Global Positioning System (GPS) receiver determined the longitude and latitude of the sampling positions. However, the non-military GPS is not accurate enough to pinpoint the sampling locations. To overcome this inaccuracy, ten readings are taken at each location (Attachment 3) then averaged and plotted on a topographical map, Attachment 4.

An asbestos sampler (sampler) was placed at the three sampling locations. The sampler consists of a filter cassette, battery powered pump and battery. The filter cassette is supported off the ground by a TV antenna tripod at a level within breathing zone of an adult. A schematic of the sampler is contained in Attachment 5. The flow is checked before and after the run.

As mentioned previously, monitoring started on July 5 and ended on July 8. Three eight (8) hour samples were taken at each site during the sampling period which started around 7:30 a.m. and ended around 3:30 p.m. Due to security, samplers were set-up each morning and removed each afternoon.

On July 9, staff sent the samples to our contract laboratory, RJ Lee Group Inc. (Lab) by United Parcel Service overnight. The Lab analyzed all samples by ARB Level 3 TEM.

2. Results

The asbestos concentration results are summarized in Attachment 6. All of the samples had detectable amounts of airborne asbestos. Airborne asbestos concentrations range from a low of 0.0009 structures per cubic centimeter (S/cc) to a high of 0.0214 S/cc. Seven of the nine samples had concentrations greater than the minimum detection limit. Over half the samples with detectable asbestos concentration had fibers with a length greater than five (5) microns. This unusually high fraction of samples with fiber lengths greater than 5 microns may be due to the close proximity of the sampler to the potholes. The first site had the highest asbestos concentration each day and had the heaviest traffic. RJ Lee supplies a computer generated count sheet for each sample. The length and width data and the asbestos type information are available on the count sheet. Copies of RJ Lee reports along with count sheets are contained in Attachment 7.

B. QUALITY CONTROL

In addition to the nine (9) samples, three Quality Control (QC) samples were submitted to the Lab. A box blank and two field blanks were taken. The box blank is a unopened cassette and is used to confirm that the original unused cassettes are not contaminated. The field blank is used to determine if the flow meter is a source of asbestos contamination. The field blank is handled like the eight hour samples. Also, only one flow check is performed. Two flowmeters were used in this study to measure the sampler's flowrate. A field blank was taken for each flowmeter. The results of the analysis of the QC Samples is contained in Attachment 6. Staff did not find any asbestos contamination.

Staff placed a label on each filter cassette which contained the sample number and other information. Staff maintained a log sheet which list the sample numbers, the sampling period, the date of sample collection, beginning and ending flowrate, and results of leak checks. A chain of custody sheet accompanied each sample. The Lab upon receiving the samples verified the number of samples received and note if the chain of custody tape on the box was broken upon receipt. In addition the Lab signed the chain of custody forms and returned the original to staff. When analyzing the sample, the Lab maintains its internal chain of custody.

C. TRAFFIC COUNTING

Staff counted traffic at the first site during the sampling period. Traffic peaked the second day (18 vehicles and 5 motorcycles) with residents stopping and to ask questions. On the third day staff spent only 80% of the time at the first site. However, the traffic count was low for that day. Attachment 8 is a tabulation of the traffic data.

D. METEOROLOGICAL DATA

Meteorological (Met) data consisted of wind speed and direction were taken only during the sampling period. The Met station was hung on the same tripod as the sampler. A schematic of the Met station is contained in Attachment 8. Staff reduced the data and prepared the wind roses for the sampling period of each sampler. However, the first hour of data were not useable because all samplers were setup before the meteorological sensors were brought online. Attachment 9 shows the wind roses for each day.

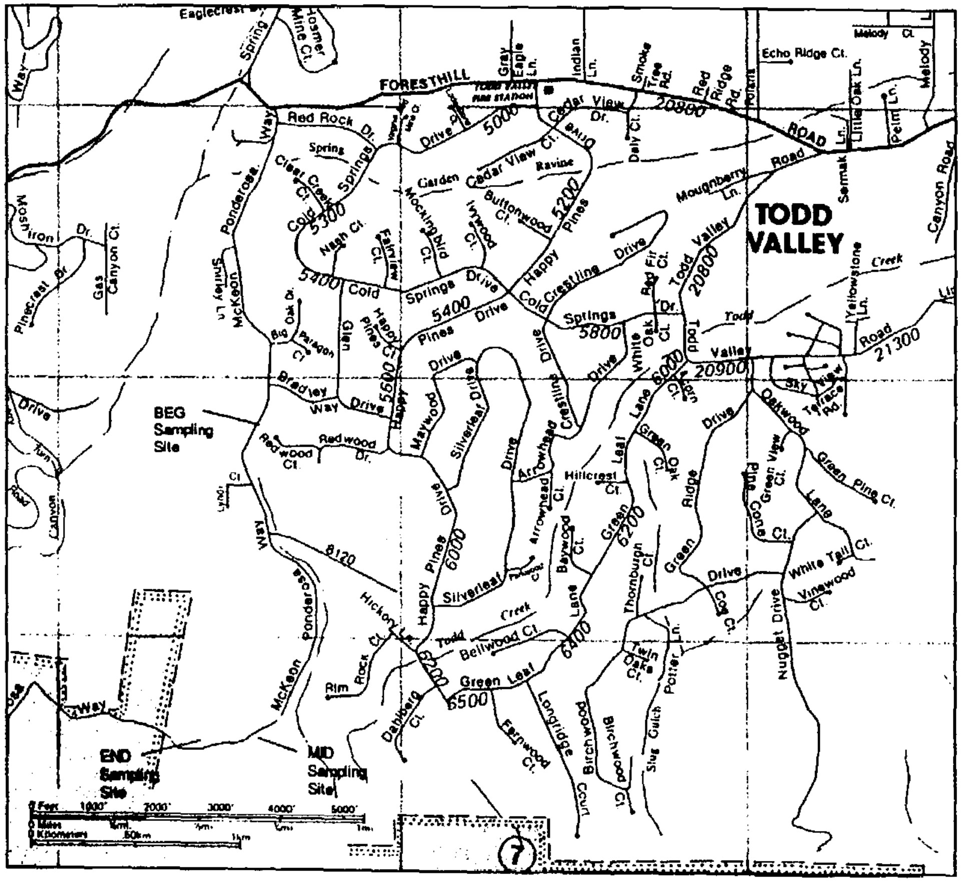
If you have questions or need more information, please contact me at 327-0900 or have your staff contact James McCormack of my staff at 322-2369.

Attachments (9)

- Attachment 1 – Street Map
- Attachment 2 – Aerial Photo's
- Attachment 3 – GPS Data
- Attachment 4 – Topographical Map
- Attachment 5 – Sampler Schematic
- Attachment 6 – Results
- Attachment 7 – RJ Lee Reports
- Attachment 8 – Traffic
- Attachment 9 – Met Data

cc: Bill Loscutoff

Attachment 1
Street Map Showing Sampling Locations



Attachment 2
Aerial Photographs of Sampling Sites

Photo of all three sampling sites.

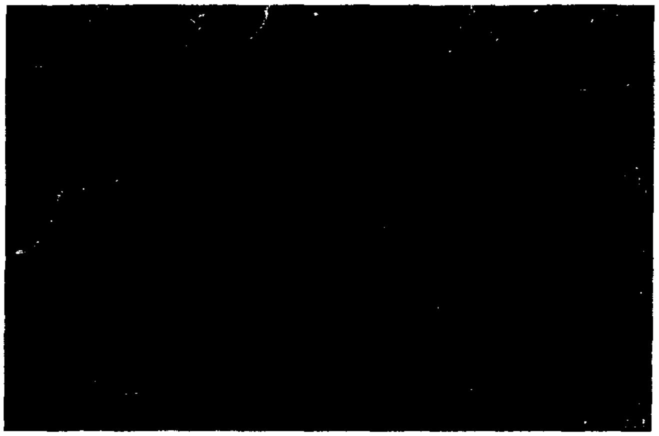


Photo of Middle and End Sampling Sites.

Photo of Beginning Sampling Site.

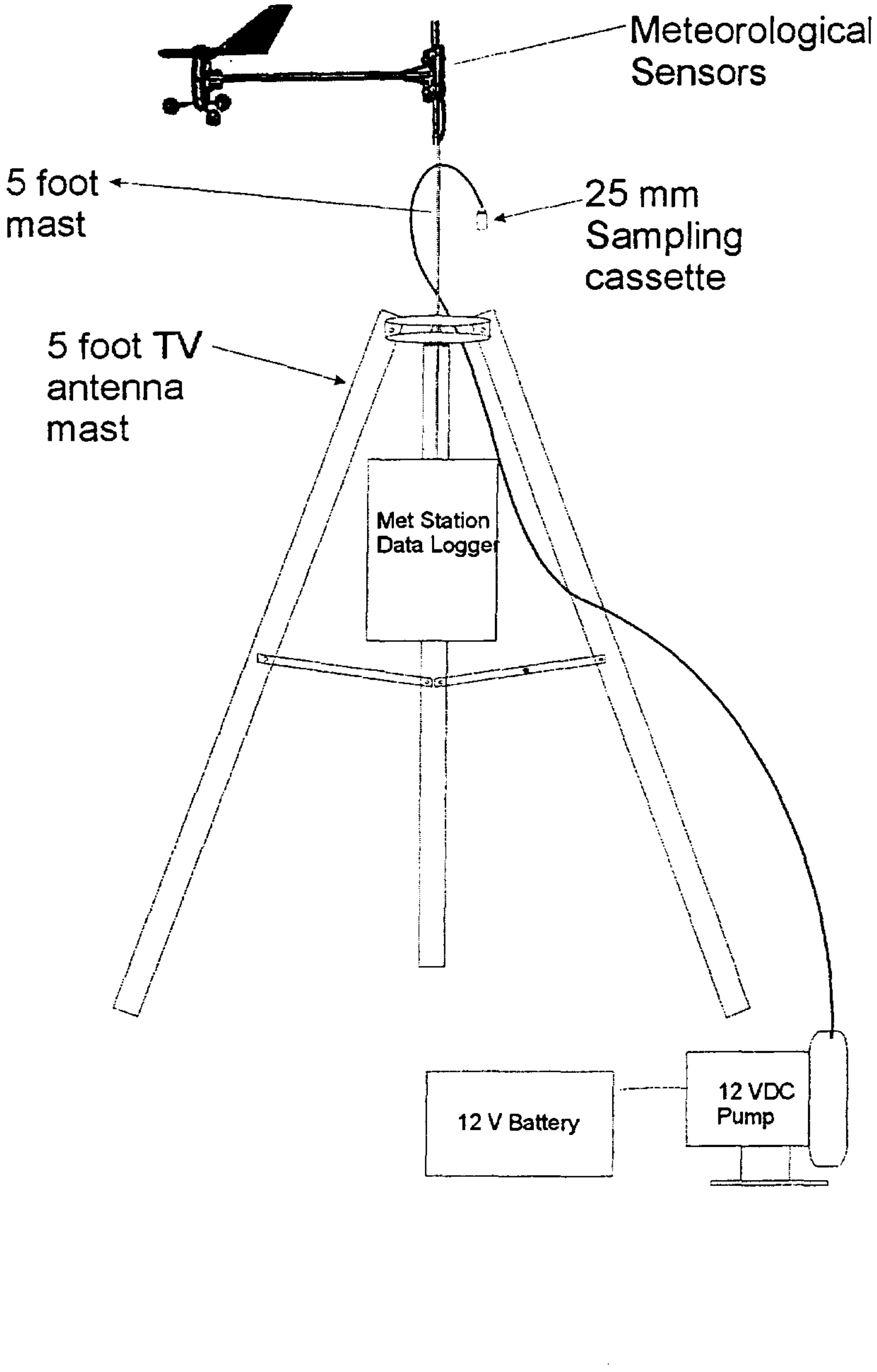
Attachment 3

Longitude and Latitude Coordinate of Sampling Sites

Sampling Location	Readings	Latitude			Longitude			Altitude
		Degrees	Minutes		Degrees	Minutes		
Beginning of McKeon Ponderosa Rd	beg0	38	59.214	N	120	54.393	W	2143
	beg1	38	59.259	N	120	54.426	W	2323
	beg2	38	59.228	N	120	54.438	W	2228
	beg3	38	59.218	N	120	54.419	W	2140
	beg4	38	59.201	N	120	54.387	W	2058
	beg5	38	59.220	N	120	54.363	W	2075
	beg6	38	59.201	N	120	54.368	W	2453
	beg7	38	59.223	N	120	54.409	W	2292
	beg8	38	59.211	N	120	54.393	W	2467
	beg9	38	59.146	N	120	54.332	W	2856
	average	38	59.212	N	120	54.393	W	2304
		38.987	——	N	120.907	——	W	
Middle of McKeon Ponderosa Rd	mid0	38	58.430	N	120	54.841	W	2448
	mid1	38	58.395	N	120	54.800	W	2006
	mid2	38	58.391	N	120	54.874	W	2178
	mid3	38	58.394	N	120	54.837	W	2346
	mid4	38	58.428	N	120	54.873	W	2386
	mid5	38	58.452	N	120	54.888	W	2417
	mid6	38	58.456	N	120	54.886	W	2496
	mid7	38	58.463	N	120	54.882	W	2406
	mid8	38	58.490	N	120	54.899	W	2265
	mid9	38	58.486	N	120	54.806		2301
	average	38	58.439	N	120	54.859	W	2325
		38.974	——	N	120.914	——	W	
End of McKeon Ponderosa Rd	end0	38	58.346	N	120	54.451	W	1978
	end1	38	58.373	N	120	54.565	W	843
	end2	38	58.387	N	120	54.465	W	2192
	end3	38	58.424	N	120	54.522	W	2473
	end4	38	58.392	N	120	54.497	W	2530
	end5	38	58.353	N	120	54.463	W	1954
	end6	38	58.358	N	120	54.465	W	1891
	end7	38	58.388	N	120	54.472	W	2094
	end8	38	58.406	N	120	54.486	W	2158
	end9	38	58.396	N	120	54.460	W	1981
	average	38	58.382	N	120	54.485	W	2009
		38.973	——	N	120.908	——	W	

Attachment 4
Topographical Map Showing Sampling Locations

Attachment 5
Airborne Asbestos Sampling Station



Attachment 6
Results of TEM Analysis

Log #	Sample #	Asbestos Concentration (Structures per Cubic Centimeter)		
		MDL	All Fibers	>5 Microns
PH-1	END-1	0.0009	0.0009	ND
PH-2	MID-1	0.0009	0.0027	ND
PH-3	BEG-1	0.0009	0.0054	0.0009
PH-4	END-2	0.0009	0.0017	0.0009
PH-5	MID-2	0.0009	0.0078	ND
PH-6	BEG-2	0.0009	0.0135	0.0051
PH-7	END-3	0.0009	0.0009	ND
PH-8	MID-3	0.0009	0.0150	0.0026
PH-9	BEG-3	0.0009	0.0214	0.0027
PH-10	BOX-1	0.0009	ND	ND
PH-11	FIELD-1	0.0009	ND	ND
PH-12	FIELD-2	0.0009	ND	ND

BEG	is acronym for Beginning of McKeon Ponderosa Way
BOX	is acronym for Box Blank
END	is acronym for End of McKeon Ponderosa Way
FIELD1	is acronym for Field Blank for Flowmeter #1
FIELD2	is acronym for Field Blank for Flowmeter #2
MDL	is acronym for Minimum Detection Limit
MID	is acronym for Middle of McKeon Ponderosa Way
ND	is acronym for none detected
S/CC	is acronym for Structures per Cubic Centimeter

Attachment 7
RJ Lee Report

RJ Lee *Group*, Inc.
530 McCormick St. • San Leandro, CA 94577
(510) 567-0480 • FAX (510) 567-0488

July 17, 1999

RECEIVED
JUL 21 1999
AIR RESOURCES BOARD
MONITORING & LABORATORY DIVISION

Mr. George Lew
California Air Resources Board
Engineering & Laboratory Branch
600 North Market Blvd
Sacramento, CA 95834

RE: TEM Asbestos Analysis Results for Samples as Shown on Test Report & Table II
RJ Lee Group Job No.: ATC907233
Customer Project No.: C-99-031

Dear Mr. Lew:

Enclosed are the results from the transmission electron microscopy (TEM) asbestos analysis for your above referenced project using CARB Level III analysis. Test Report lists each sample identification number, filter area, sample volume, area analyzed, structure counts, analytical sensitivity, and the concentration of asbestos. Table II lists the same information as Test Report for structures ≥ 5μm in length. Table V lists the 95% confidence limits for the analyses, based on the Poisson distribution. Count sheets are included.

These results are submitted pursuant to RJ Lee Group's current terms and conditions of sale, including the commpany's standard warranty and limitation of liability provisions and no responsibility or liability is assumed for the manner in which the results are used or interpreted.

Should you have any questions, please feel free to call.

Sincerely,

B. Thomas
Bernard Thomas
Project Manager

BT/sjb
Enclosures

Test Report

Total Asbestos Structure Concentration

TEM Level III Analysis

Project ATC907233

RJ Lee Group Sample Number	Client Sample Number	Filter Area (sq mm)	Volume ‡ (Liters)	Area Analyzed (sq mm)	Structures		Analytical Sensitivity †		Concentration		Analysis Date
					Chr	Amp	(S/sq. mm)	(S/cc)	(S/sq. mm)	(S/cc)	
1822525CT	PH-1-END-1	385	4752.00	0.0921	1	0	10.9	0.0009	10.9	0.0009	7/15/99
1822526CT	PH-2-MID-1	385	4680.00	0.0921	3	0	10.9	0.0009	32.6	0.0027	7/15/99
1822527CT	PH-3-BEG-1	385	4608.00	0.0921	6	0	10.9	0.0009	65.2	0.0054	7/15/99
1822528CT	PH-4-END-2	385	4920.00	0.0921	2	0	10.9	0.0009	21.7	0.0017	7/15/99
1822529CT	PH-5-MID-2	385	4800.00	0.0921	9	0	10.9	0.0009	97.8	0.0078	7/15/99
1822530CT	PH-6-BEG-2	385	4944.00	0.0921	16	0	10.9	0.0008	173.8	0.0135	7/15/99
1822531CT	PH-7-END-3	385	4632.00	0.0921	1	0	10.9	0.0009	10.9	0.0009	7/15/99
1822532CT	PH-8-MID-3	385	4752.00	0.0921	17	0	10.9	0.0009	184.7	0.0150	7/15/99
1822533CT	PH-9-BEG-3	385	4680.00	0.0921	24	0	10.9	0.0009	260.7	0.0214	7/15/99
1822534CT	PH-10-BOX-1	385	4800.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	7/15/99
1822535CT	PH-11-FIELD-1	385	4800.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	7/15/99
1822536CT	PH-12-FIELD-2	385	4800.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	7/15/99

‡ Volumes provided by California Air Resources Board for Project C-99-031 were used to calculate analytical results and sensitivities.

†Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.

Chr - Chrysotile, Amp - Amphibole

Samples received on: Monday, July 12, 1999

* Results Less Than Analytical Sensitivity.

N/A - Sample not analyzed.

Authorized Signature

Bernard Thomas, Project Manager

Date Date Saturday, July 17, 1999

Table II

Asbestos Concentration for Structures ≥ 5 µm in Length
TEM Level III Analysis
Project ATC907233

RJ Lee Group Sample Number	Client Sample Number	Filter Area (sq mm)	Volume ‡ (Liters)	Area Analyzed (sq mm)	Structures ≥5 µm		Analytical Sensitivity †		Concentration for Structures ≥ 5 µm		Analysis Date
					Chr	Amp	(S/sq. mm)	(S/cc)	(S/sq. mm)	(S/cc)	
1822525CT	PH-1-END-1	385	4752.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	7/15/99
1822526CT	PH-2-MID-1	385	4680.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	7/15/99
1822527CT	PH-3-BEG-1	385	4608.00	0.0921	1	0	10.9	0.0009	10.9	0.0009	7/15/99
1822528CT	PH-4-END-2	385	4920.00	0.0921	1	0	10.9	0.0009	10.9	0.0009	7/15/99
1822529CT	PH-5-MID-2	385	4800.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	7/15/99
1822530CT	PH-6-BEG-2	385	4944.00	0.0921	6	0	10.9	0.0008	65.2	0.0051	7/15/99
1822531CT	PH-7-END-3	385	4632.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	7/15/99
1822532CT	PH-8-MID-3	385	4752.00	0.0921	3	0	10.9	0.0009	32.6	0.0026	7/15/99
1822533CT	PH-9-BEG-3	385	4680.00	0.0921	3	0	10.9	0.0009	32.6	0.0027	7/15/99
1822534CT	PH-10-BOX-1	385	4800.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	7/15/99
1822535CT	PH-11-FIELD-1	385	4800.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	7/15/99
1822536CT	PH-12-FIELD-2	385	4800.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	7/15/99

‡ Volumes provided by California Air Resources Board for Project C-99-031 were used to calculate analytical results and sensitivities.
†Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.

Chr - Chrysotile, Amp - Amphibole
Samples received on: Monday, July 12, 1999
* Results Less Than Analytical Sensitivity.
N/A - Sample not analyzed.

Authorized Signature
Bernard Thomas, Project Manager
Date Date Saturday, July 17, 1999

RJ Lee Group, Inc.
Bay Area Lab

530 McCormick Street
San Leandro, CA 94577

Phone (510) 567-0480
Fax (510) 567-0488

Table V

Total Poisson Asbestos Concentrations
TEM Level III Analysis
Project ATC907233

Sample Number	Client Sample Number	Actual Counts	Poisson Range		Lower Concentration Bounds ‡		Upper Concentration Bounds ‡		Analysis Date
			Lower	Upper	S/sq mm	S/cc	S/sq mm	S/cc	
1822525CT	PH-1-END-1	1	0	6	0.00	0.0000	65.18	0.0053	7/15/99
1822526CT	PH-2-MID-1	3	1	9	10.86	0.0009	97.76	0.0080	7/15/99
1822527CT	PH-3-BEG-1	6	2	13	21.73	0.0018	141.21	0.0118	7/15/99
1822528CT	PH-4-END-2	2	0	7	0.00	0.0000	76.04	0.0060	7/15/99
1822529CT	PH-5-MID-2	9	4	17	43.45	0.0035	184.66	0.0148	7/15/99
1822530CT	PH-6-BEG-2	16	9	26	97.76	0.0076	282.43	0.0220	7/15/99
1822531CT	PH-7-END-3	1	0	6	0.00	0.0000	65.18	0.0054	7/15/99
1822532CT	PH-8-MID-3	17	10	27	108.63	0.0088	293.29	0.0238	7/15/99
1822533CT	PH-9-BEG-3	24	15	36	162.94	0.0134	391.06	0.0322	7/15/99
1822534CT	PH-10-BOX-1	0	0	4	<10.86*	<0.0009*	43.45	0.0035	7/15/99
1822535CT	PH-11-FIELD-1	0	0	4	<10.86*	<0.0009*	43.45	0.0035	7/15/99
1822536CT	PH-12-FIELD-2	0	0	4	<10.86*	<0.0009*	43.45	0.0035	7/15/99

‡ Volumes provided by California Air Resources Board for Project C-99-031 were used to calculate analytical results and sensitivities.
†Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.
Samples received on: Monday, July 12, 1999
Chr - Chrysotile, Amp - Amphibole
* Results Less Than Analytical Sensitivity.
N/A - Sample not analyzed.

Authorized Signature ______________________
Bernard Thomas, Project Manager
Date Saturday, July 17, 1999

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC907233	**RJL QA Number**	CQ13189
RJL Sample #	1822525CT	**Grid Openings**	10
Client Sample #	PH-1-END-1	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4752.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	1	2.00	0.20	Chrysotile	BCM			0605		
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC907233	**RJL QA Number**	CQ13189
RJL Sample #	1822526CT	**Grid Openings**	10
Client Sample #	PH-2-MID-1	**Total Asbestos**	3
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4680.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	1	3.70	0.30	Chrysotile	B			X		
7	0			NSD						
8	0			NSD						
9	1	3.00	0.10	Chrysotile	M			X		
9	2	3.20	0.15	Chrysotile	BCM			0606		
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC907233	**RJL QA Number**	CQ13189
RJL Sample #	1822529CT	**Grid Openings**	10
Client Sample #	PH-5-MID-2	**Total Asbestos**	9
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4800.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	1.50	0.10	Chrysotile	CM			X		
2	1	2.00	0.18	Chrysotile	BM			X		
3	1	2.00	0.20	Chrysotile	BM			0608		
4	1	1.20	0.10	Chrysotile	MI			X		
5	0			NSD						
6	1	1.00	0.10	Chrysotile	M			X		
6	2	0.60	0.08	Chrysotile				X		
6	3	3.80	0.15	Chrysotile	BCM			X		
7	1	1.20	0.12	Chrysotile	BM			X		
8	0			NSD						
9	0			NSD						
10	1	2.00	0.20	Chrysotile	BM			X		

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC907233	**RJL QA Number**	CQ13189
RJL Sample #	1822531CT	**Grid Openings**	10
Client Sample #	PH-7-END-3	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4632.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	1	3.70	0.50	Chrysotile	B			0610		
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee *Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC907233**	**RJL QA Number**	CQ13189
RJL Sample #	**1822531CT**	**Grid Openings**	10
Client Sample #	PH-7-END-3	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4632.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	1	3.70	0.50	Chrysotile	B			0610		
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee *Group* , Inc

Count Sheet

Client Name California Air Resources Board
Project Number ATC907233
RJL Sample # 1822532CT
Client Sample # PH-8-MID-3
Microscope 1200 EX
Accelerating Volt 100 Kv
Magnification 20000 X
Analyst YZ
EDS Disk

RJL QA Number CQ13189
Grid Openings 10
Total Asbestos 17
Total Non-Asbestos 0
Filter CE 385 mm^2
Volume 4752.0 Liters
Grid Opening Area 0.0092 mm^2
Dilution Factor 1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	1	1.75	0.10	Chrysotile	0611					
3	0			NSD						
4	1	2.30	0.25	Chrysotile	BM			X		
4	2	2.50	0.10	Chrysotile				X		
4	3	5.50	0.13	Chrysotile	BM			X		
4	4	8.50	0.80	Chrysotile	BCM			X		
5	1	1.00	0.10	Chrysotile				X		
5	2	1.50	0.14	Chrysotile	BCM			X		
5	3	2.10	0.25	Chrysotile	BM			X		
5	4	0.60	0.12	Chrysotile	B			X		
5	5	0.70	0.17	Chrysotile	M			X		
5	6	1.20	0.08	Chrysotile				X		
6	1	0.80	0.08	Chrysotile				X		
7	1	2.10	0.14	Chrysotile	BC			X		
7	2	7.50	0.14	Chrysotile	BM			X		
8	0			NSD						
9	1	0.75	0.12	Chrysotile	BM			X		
10	1	1.50	0.07	Chrysotile				X		
10	2	1.40	0.14	Chrysotile	BM			X		

NSD - No Structures Detected

RJ Lee*Group*, Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC907233	**RJL QA Number**	CQ13189
RJL Sample #	1822533CT	**Grid Openings**	10
Client Sample #	PH-9-BEG-3	**Total Asbestos**	24
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4680.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	2.50	0.18	Chrysotile	BM			X		
1	2	2.20	0.20	Chrysotile				0612		
2	0			NSD						
3	1	2.70	0.10	Chrysotile	M			X		
4	1	7.00	0.20	Chrysotile	B			X		
4	2	1.50	0.20	Chrysotile	BM			X		
4	3	1.50	0.20	Chrysotile	BM			X		
4	4	1.20	0.40	Chrysotile	BM			X		
5	1	0.60	0.12	Chrysotile	BM			X		
5	2	0.70	0.10	Chrysotile	M			X		
5	3	2.00	0.12	Chrysotile	BC			X		
6	1	9.00	0.12	Chrysotile	BCM			X		
6	2	2.70	0.25	Chrysotile	BM			X		
6	3	2.10	0.10	Chrysotile	M			X		
6	4	3.50	0.12	Chrysotile	BM			X		
6	5	1.20	0.12	Chrysotile	BM			X		
7	1	9.50	0.75	Chrysotile	BM			X		
7	2	2.90	0.20	Chrysotile	B			X		
7	3	1.20	0.12	Chrysotile	BM			X		
7	4	2.00	0.12	Chrysotile	BCM			X		
7	5	2.50	0.12	Chrysotile	BM			X		
8	0			NSD						
9	1	1.20	0.15	Chrysotile	BM			X		
9	2	2.90	0.30	Chrysotile	BCM			X		
10	1	3.20	0.12	Chrysotile	BM			X		
10	2	3.00	0.50	Chrysotile	BCM			X		

NSD - No Structures Detected

RJ Lee*Group*, Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC907233	**RJL QA Number**	CQ13189
RJL Sample #	1822534CT	**Grid Openings**	10
Client Sample #	PH-10-BOX-1	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4800.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC907233**	**RJL QA Number**	CQ13189
RJL Sample #	**1822535CT**	**Grid Openings**	10
Client Sample #	PH-11-FIELD-1	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4800.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee *Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC907233**	**RJL QA Number**	CQ13189
RJL Sample #	**1822536CT**	**Grid Openings**	10
Client Sample #	PH-12-FIELD-2	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4800.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

Air Resources Board

Alan C. Lloyd, Ph.D.
Chairman
2020 L Street • P.O. Box 2815 • Sacramento, California 95812 • www.arb.ca.gov

Winston H. Hickox
Secretary for Environmental Protection

Gray Davis
Governor

July 9, 1999

Bernard Thomas
Project Leader
RJ Lee Group
530 McCormick St.
San Leandro, CA 94577

Dear Mr. ~~Thomas~~ BERNARD:

Per our Contract, enclosed are 12 samples for TEM analysis using ARB Level 3 analysis. **I need these samples analyzed within 48 hours from receipt by your laboratory.** If you cannot meet this analysis time frame please contact me at (916) 263-2060. Please use the ARB Log # as the sample # in your tracking system. I also want to pick up all analyzed Cassettes and Bulk Samples on Thursday, July 15, 1999. I am sending Matt Lettau of my staff to pick up the samples. He will arrive around 11:00am. He will bring the necessary chain of custody forms to transfer the custody of the samples.

Please fax the preliminary results to George Lew at (916) 263-2067. Send the final results along with the completed chain of custody form to:

George Lew, Chief
Engineering and Laboratory Branch
Air Resources Board
P. O. Box 2815
600 North Market Blvd
Sacramento, CA 95814

If you have any questions call me at (916) 263-2060.

Sincerely,

James E McCormack

James E. McCormack
Air Resources Engineer
Monitoring and Laboratory Division

California Environmental Protection Agency
Printed on Recycled Paper

RJ Lee*Group*, Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC907233	**RJL QA Number**	CQ13189
RJL Sample #	1822527CT	**Grid Openings**	10
Client Sample #	PH-3-BEG-1	**Total Asbestos**	6
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4608.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	2.10	0.12	Chrysotile	BM			X		
1	2	5.00	0.50	Chrysotile	BCM			X		
2	0			NSD						
3	0			NSD						
4	1	4.20	0.70	Chrysotile	BM			0607		
5	0			NSD						
6	0			NSD						
7	1	1.65	0.12	Chrysotile	BM			X		
8	1	2.00	0.12	Chrysotile	BCM			X		
9	1	2.00	0.14	Chrysotile	BM			X		
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc
Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC907233	**RJL QA Number**	CQ13189
RJL Sample #	1822528CT	**Grid Openings**	10
Client Sample #	PH-4-END-2	**Total Asbestos**	2
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4920.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	1	1.50	0.12	Chrysotile	B			X		
5	1	6.40	0.30	Chrysotile	BCM			X		
6	0			NSD						
7	0			NSD						
8	1	1.00	0.10	Ambiguous	M1					
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

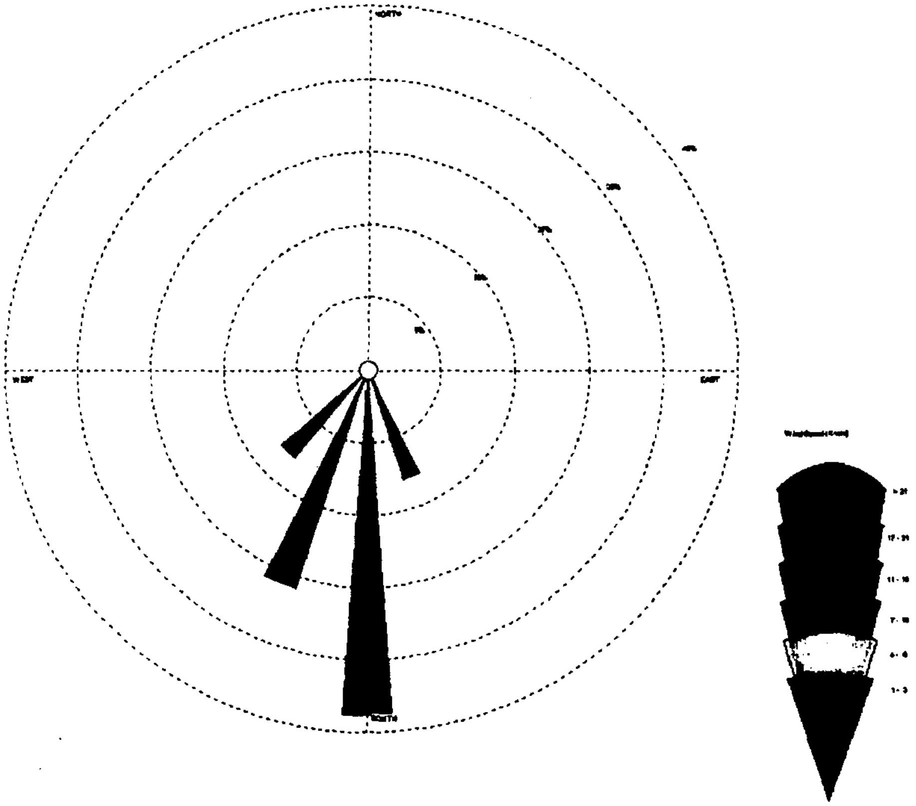
Attachment 8
Observed Traffic at the "Beginning Site" On McKeon Ponderosa Way*

Date	Day of Week	Vehicles	Motorcycles
July 5, 1999	Tuesday	8	6
July 6, 1999	Wednesday	18	5
July 7, 1999	Thursday	5**	2**

* Sampling occurred during the hours of 0730 to 1530 hours.

** Wasn't present all the time during sampling. Took two hours to photograph sampling sites and take distance measurements.

Attachment 9
Meteorological Data
Wind Rose Plot
Beginning of abandoned road near Foresthill - 1



Company Name
ARB

Display
Wind Speed

Avg. Wind Speed
1.57 Knots

Orientation
Direction blowing from

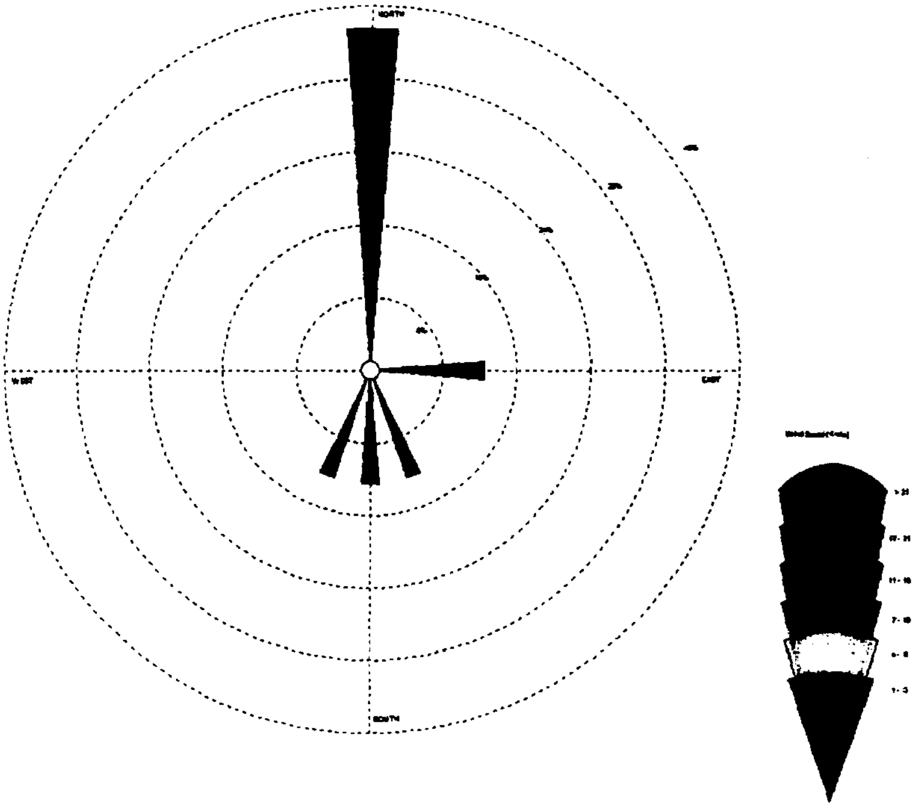
Units
Knots

Calm Winds
0.00%

Plot Year-Date-Time
7/6/99 1000 to 7/6/99 1600

Sample ID
Beg-1

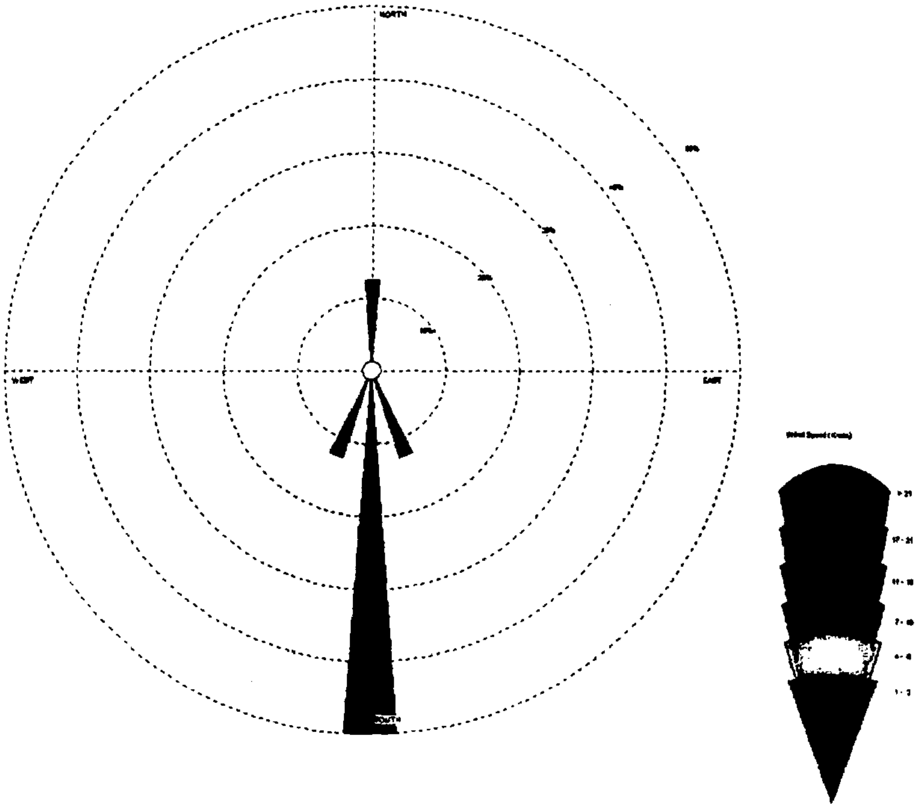
Attachment 9 cont'd
Meteorological Data
Wind Rose Plot
Beginning of abandoned road near Foresthill - 2



Company Name **ARB**	Orientation **Direction blowing from**	Plot Year-Date-Time **7/7/99 0800 to 7/7/99 1500**
Display **Wind Speed**	Units **Knots**	Sample ID **Beg-2**
Avg. Wind Speed **1.43 Knots**	Calm Winds **12.5%**	

Attachment 9 cont'd
Meteorological Data
Wind Rose Plot

Beginning of abandoned road near Foresthill - 3



Company Name
ARB

Display
Wind Speed

Avg. Wind Speed
1.71 Knots

Orientation
Direction blowing from

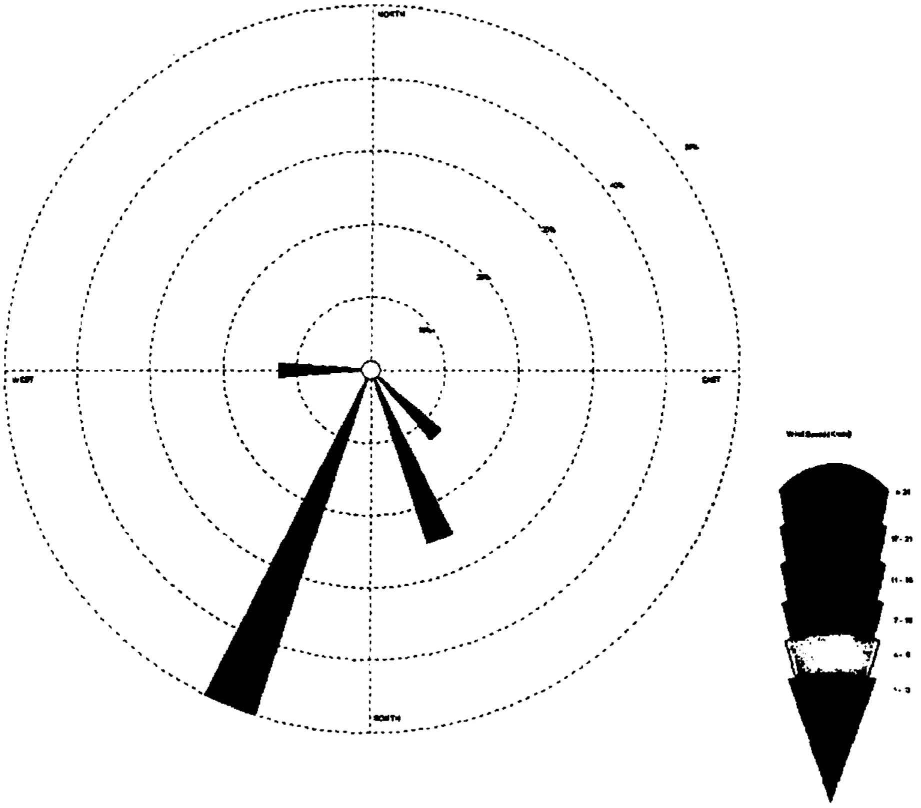
Units
Knots

Calm Winds
12.5%

Plot Year-Date-Time
7/8/99 0800 to 7/8/99 1500

Sample ID
Beg-3

Attachment 9 cont'd
Meteorological Data
Wind Rose Plot
Middle of abandoned road near Foresthill - 1



Company Name
ARB

Display
Wind Speed

Avg. Wind Speed
2.00 Knots

Orientation
Direction blowing from

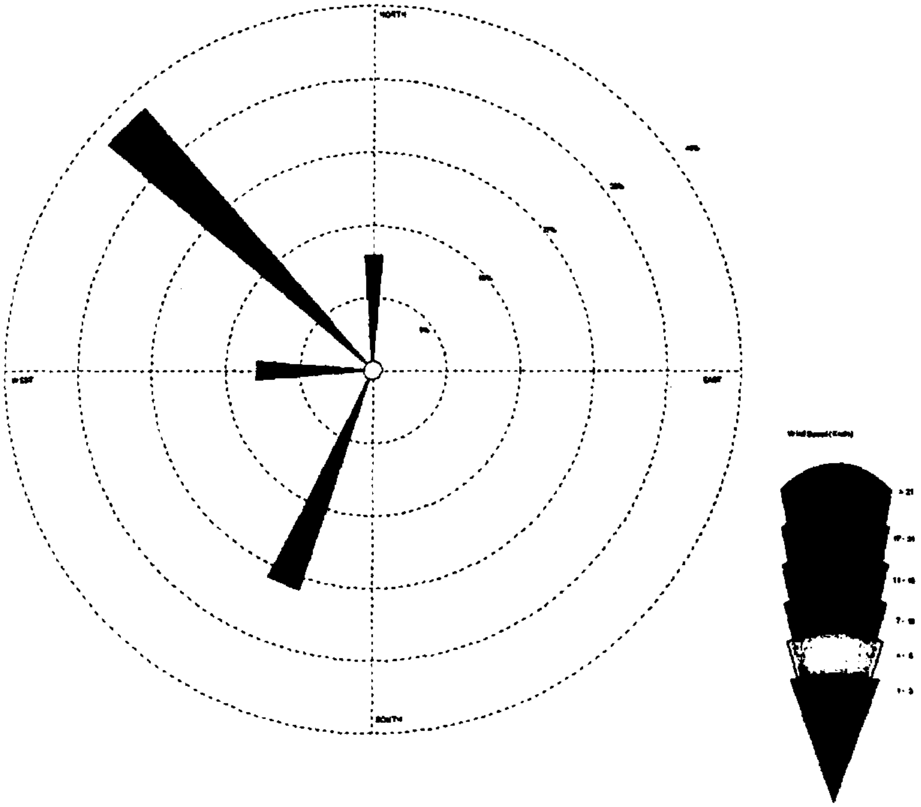
Units
Knots

Calm Winds
0.00%

Plot Year-Date-Time
7/6/99 0900 to 7/6/99 1600

Sample ID
Mid-1

Attachment 9 cont'd
Meteorological Data
Wind Rose Plot
Middle of abandoned road near Foresthill - 2



Company Name
ARB

Orientation
Direction blowing from

Plot Year-Date-Time
7/7/99 0900 to 7/7/99 1500

Display
Wind Speed

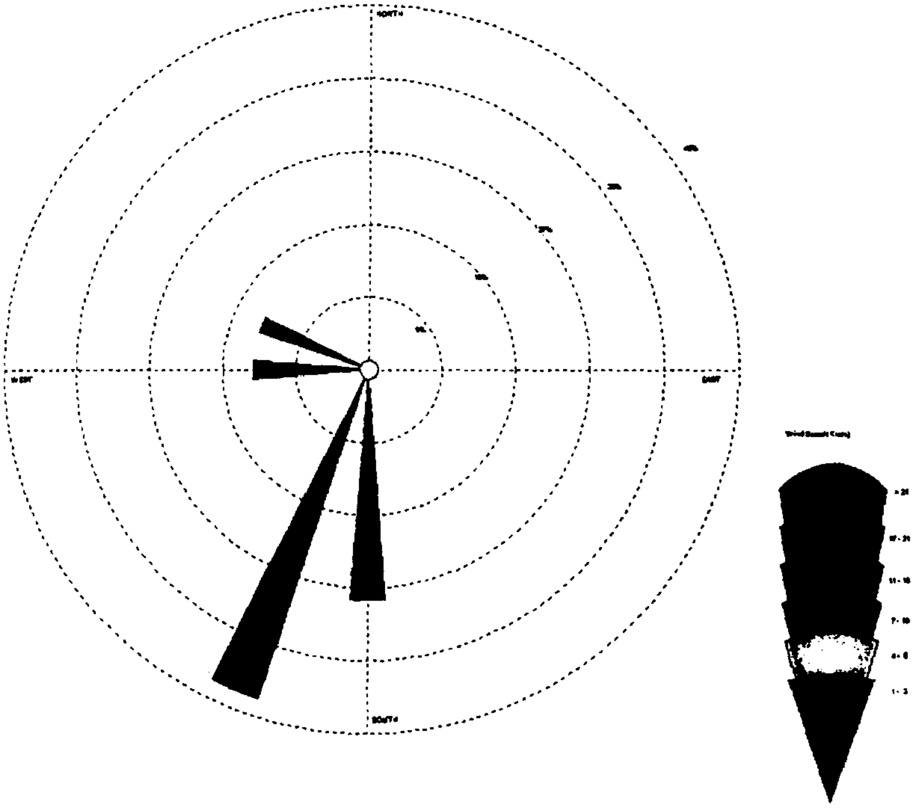
Units
Knots

Sample ID
Mid-2

Avg. Wind Speed
2.00 Knots

Calm Winds
0.00%

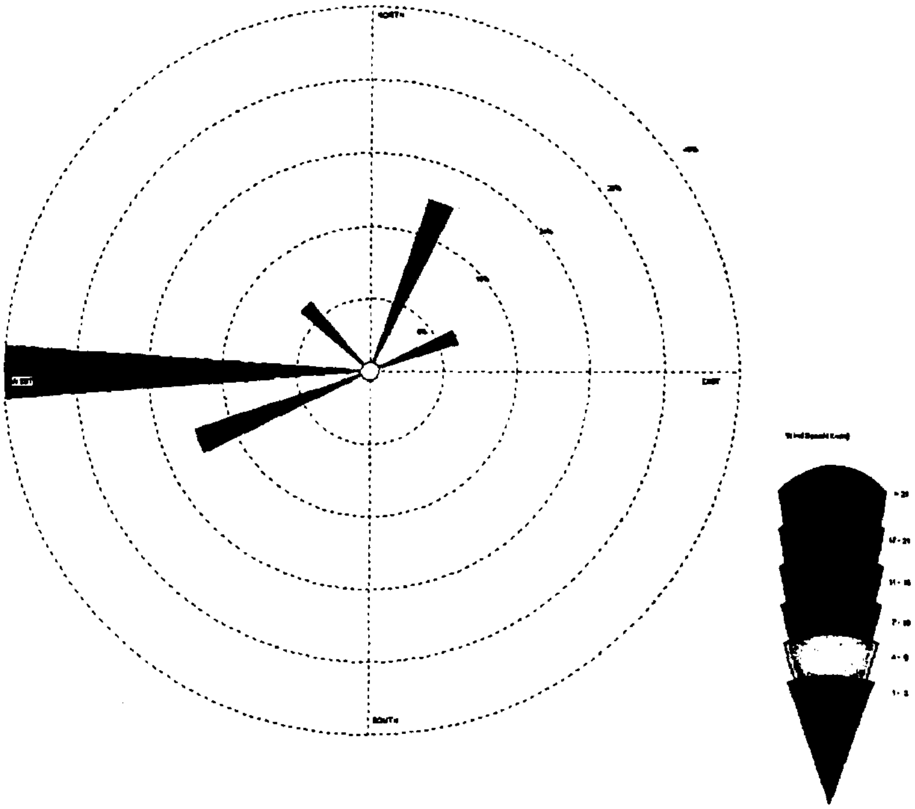
Attachment 9 cont'd
Meteorological Data
Wind Rose Plot
Middle of abandoned road near Foresthill - 3



Company Name **ARB**	Orientation **Direction blowing from**	Plot Year-Date-Time **7/8/99 0900 to 7/8/99 1500**
Display **Wind Speed**	Units **Knots**	Sample ID **Mid-3**
Avg. Wind Speed **2.14 Knots**	Calm Winds **0.00%**	

Attachment 9 cont'd
Meteorological Data
Wind Rose Plot

End of abandoned road near Foresthill - 1



Company Name
ARB

Display
Wind Speed

Avg. Wind Speed
2.30 Knots

Orientation
Direction blowing from

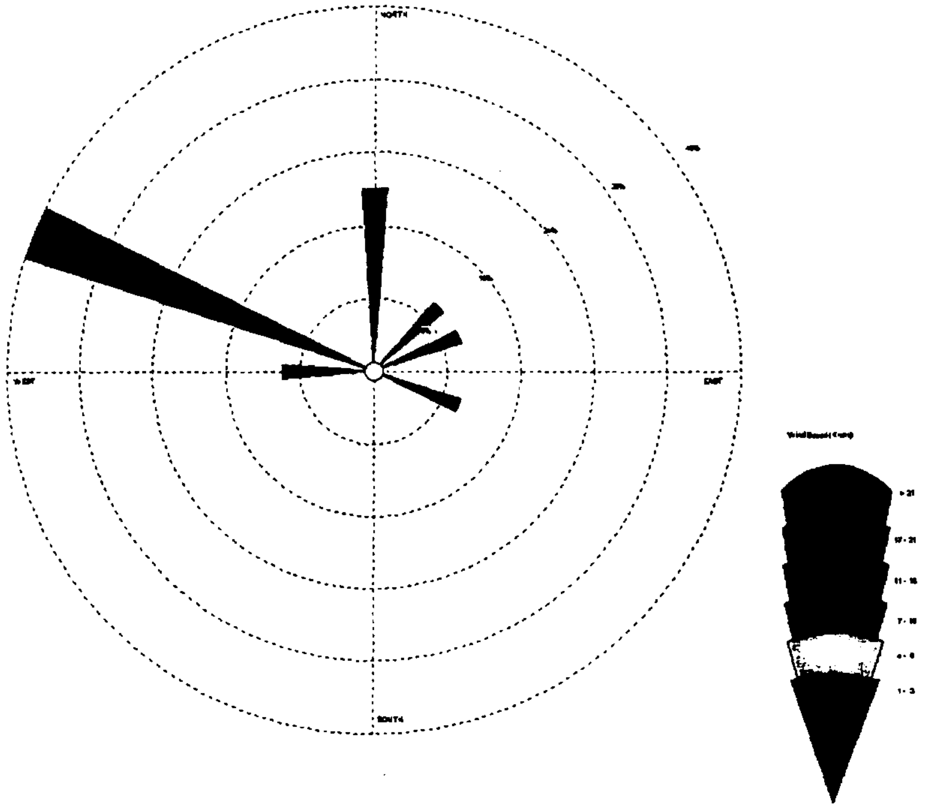
Units
Knots

Calm Winds
0.00%

Plot Year-Date-Time
7/6/99 0700 to 7/6/99 1600

Sample ID
End-1

Attachment 9 cont'd
Meteorological Data
Wind Rose Plot
End of abandoned road near Foresthill - 2



Company Name
ARB

Display
Wind Speed

Avg. Wind Speed
2.40 Knots

Orientation
Direction blowing from

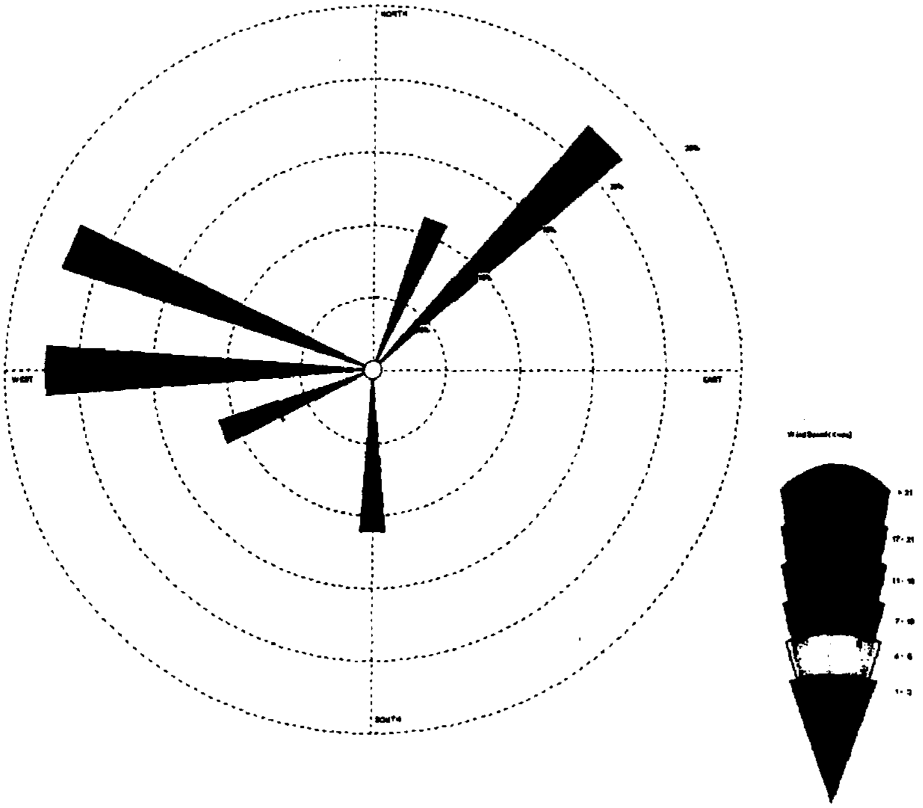
Units
Knots

Calm Winds
0.00%

Plot Year-Date-Time
7/7/99 0700 to 7/7/99 1600

Sample ID
End-2

Attachment 9 cont'd
Meteorological Data
Wind Rose Plot
End of abandoned road near Foresthill - 3



Company Name **ARB**	Orientation **Direction blowing from**	Plot Year-Date-Time **7/8/99 0700 to 7/8/99 1500**
Display **Wind Speed**	Units **Knots**	Sample ID **End-3**
Avg. Wind Speed **2.00 Knots**	Calm Winds **0.00%**	

Appendix E-2-B

Air Resources Board
Bulk Sampling Of McKeon-Ponderosa Road
Pothole Road Study

Air Resources Board

Alan C. Lloyd, Ph.D.
Chairman
2020 L Street • P.O. Box 2815 • Sacramento, California 95812 • www.arb.ca.gov

Winston H. Hickox
Agency Secretary

Gray Davis
Governor

MEMORANDUM

TO: Dan Donohoue, Chief
Emissions Assessment Branch
Stationary Source Division

FROM: George Lew, Chief
Engineering and Laboratory Branch
Monitoring and Laboratory Division

DATE: March 23, 2000

SUBJECT: RESULTS OF BULK SAMPLING OF UNPAVED ROADS

This memorandum transmits the results of analyses of bulk samples taken from unpaved or aggregate covered roads in El Dorado County and Placer County. Samples were taken from three unpaved county roads in El Dorado County, a pothole consumed section of an abandoned county road in Placer County, a private homeowner association road in El Dorado County, and a school bus stop and turn-around whose surface is covered with serpentine aggregate. A total of seven samples were collected in accordance with Air Resources Board (ARB) Test Method 435.

The bulk samples are representative of the area of road sampled. The analysis was performed by ARB's contract lab RJ Lee in San Leandro. At ARB's direction, R. J. Lee modified the ARB Test Method 435 by performing a 1000 point count analysis instead of a 400 point count as required by the test method. This 1000 point count requirement is more stringent than the 400 count procedure and is therefore an acceptable modification of Method 435. The results are tabulated in Attachment I. The report from RJ Lee is attached (Attachment II). A map showing the approximate location of the roads sampled is also attached (Attachment III).

Ten roads in El Dorado County, as follows, were identified as being non-paved county maintained roads; South Shingle Road, Farnham Ridge Road, Indian Diggins Road, Consumnes Mine Road, Park Creek Road, Goose Flat Road, Mt. Murphy Road, Bayne Road, Bear Creek Road and Breedlove Road. The roads were identified by a contractor in a report (Attachment IV) to the El Dorado County Department of Transportation. Staff of the Testing Section (MLD) and Industrial Section (SSD) performed a site assessment of the identified county maintained roads. Only three of the roads had a section of serpentine-like aggregate. One of the three roads had two sections of serpentine-like aggregate. Thus, A total of four bulk samples were taken one each at Breedlove Road, Bear Creek Road and two at Bayne Road. One sample was taken from each section of road with serpentine-like aggregate. Bulk samples were of loose road material. RJ Lee reported that the asbestos content was 0.1% or less in the four samples.

The serpentine aggregate road base material exposed by the potholes at the McKeon Ponderosa Way, had an asbestos concentration of 0.2%. In July 1999, MLD staff conducted ambient air monitoring on this road (results transmitted to Todd Wong in a memorandum dated September 4, 1999). The purpose of the air monitoring was to determine the asbestos exposure from local traffic driving across the road base material exposed by the potholes. The bulk samples were taken near the air-monitoring site which showed the highest average airborne asbestos concentration.

A bulk sample from Moonbeam Lane in El Dorado County was also collected in accordance with ARB Test Method 435. Attachment III shows the approximate location of the private road. The road was sampled because it had been scraped clean of serpentine aggregate material. However, a fine powder of serpentine was present on the road. The bulk sample was a representative sample of the loose material on a thirty-foot section of the road. RJ Lee reported that the bulk sample contained 0.8% asbestos.

A school district in El Dorado County spread serpentine aggregate at a school bus stop on Sliger Mine Road. The turn-around was sampled in accordance with ARB Test Method 435. The RJ Lee Report states that the asbestos content was 1.2%.

If you have questions, comments or need further information, please contact me at 327-0900.

Attachments (4)

cc: Bill Loscutoff

Attachment I
Results of Bulk Sampling

Log Number	Sample Number	Sampling Location (Road Name)	Asbestos Concentration
1	BR-1	Baynes Road 1 section	ND
2	BR-2	Baynes Road 2 section	ND
3	BR	Bredlove Road	0.1%
4	BCR	Bear Creek Road	ND
5	SMR	Sliger Mine Road (School Bus Turn-Around)	1.2%
6	ML	Moonbeam Lane	0.8%
7	FH-1	McKeon Ponderosa Way	0.2%

ND - No Asbestos Detected

Attachment II
RJ Lee Report

RJ Lee*Group*, Inc.

530 McCormick Street • San Leandro, CA 94577
510/567-0480 • FAX 510/567-0488

February 24, 2000

Mr. George Lew
California Air Resources Board
P.O. Box 2815
1900 14th Street
Sacramento, CA 95834

RE PLM Point Count Asbestos Results for Samples as Shown on Table I
RJ Lee Group, Inc. Job No. AOC911097-PC
Client P.O./Job Number: C-99-103
Client Job Name/Location: C-99-103

Dear Mr. Lew

Due to typographical errors, we are rescinding the previous report from RJ Lee Group, Inc. for the above referenced samples. Enclosed are the results from the polarized light microscopy (PLM) asbestos analysis of the above referenced samples. Samples were analyzed in accordance with guidelines set forth in the State of California, Air Resources Board (ARB), Test Method 435, Determination of Asbestos Content of Serpentine Aggregate (06/06/91).

Table I lists each sample identification number, gross sample description, type(s) and concentration of asbestos, type(s) and concentration of non-asbestos fibers, major components and concentration of non-fibrous material (NFM), sample run date, analyst, and the number of asbestos points counted in 1000 total points. Asbestos concentrations are given in percents to the nearest 0.1%.

The ARB Method 435, Section 8.3 lists two exceptions to the point count rule. Exception I states: "If the sample is suspected of containing no asbestos a visual technique can be used to report that the sample does not contain asbestos." If the sample is point counted, and asbestos is observed but not counted, the sample will be reported as containing <0.1% asbestos. Exception II states: "If the sample is suspected to have an asbestos content in excess of ten percent, a visual technique can be used to report that the sample contains greater than ten percent asbestos." In the case of Exception II, the visual technique allowed in the National Institute of Standards and Technology's (NIST) National Voluntary Laboratory Accreditation Program (NVLAP), Bulk Asbestos Handbook (NIST publication number NISTIR 88-3879, 10/88) will be followed. If either exception is used it will be noted under the Asb/Points category of Table I.

RJ Lee Group, Inc. is accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) (NVLAP Participant Number 1208-2) for bulk asbestos fiber analysis (PLM), and by the California Department of Health Services, Environmental Laboratory Accreditation Program (CALELAP) for bulk asbestos analysis. Neither the NVLAP Accreditation of this laboratory nor this report may be used to claim product endorsement by NVLAP or any agency of the U.S.

These results are submitted pursuant to RJ Lee Group's current terms and conditions of sale, including the company's standard warranty and limitation of liability provisions and no responsibility or liability is assumed for the manner in which the results are used or interpreted. Unless notified in writing to return the samples covered by this report, RJ Lee Group, Inc. will store the samples until they are picked up by a California Air Resources Board representative. A shipping and handling fee will be assessed for the return of any samples.

Sincerely,

Stephen S. Yata
Geologist

SSY/sjb

Monroeville, PA • San Leandro, CA • Washington, DC • Richland, WA

Test Report - California Air Resources Board

Polarized Light, Point Count Analysis Results

Project AOC911097-PC

E-2-B-6

		Asbestos						Nonasbestos						
Sample Number	Client Sample Number	Chrysotile	Amosite	Crocidolite	Anthophyllite	Tremolite	Actinolite	Cellulose	Mineral Wool	Fibrous Glass	Synthetic Fibers	Other Fibers	NonFibrous Material	Run Date Analyst
1700069CPL	1-BR-1	-	-	-	-	-	-	-	-	-	-	-	100 %	11/6/99
Grey dirt					*NFM:*	, Misc. Part.								SS
													Asb/Points	0/1000
1700070CPL	2-BR-2	-	-	-	-	-	-	-	-	-	-	-	100 %	11/6/99
Grey dirt					*NFM:*	, Misc. Part.								SS
													Asb/Points	0/1000
1700071CPL	3-BR	0.1 %	-	-	-	-	-	-	-	-	-	-	99.9 %	11/6/99
Grey dirt					*NFM:*	, Misc. Part.								SS
													Asb/Points	1/1000
1700072CPL	4-3CR	-	-	-	-	-	-	-	-	-	-	-	100 %	11/6/99
Grey dirt					*NFM:*	, Misc. Part.								SS
													Asb/Points	0/1000
1700073CPL	5-SMR	1.2 %	-	-	-	-	-	-	-	-	-	-	98.8 %	11/6/99
Grey dirt					*NFM:*	, Misc. Part.								SS
													Asb/Points	12/1000
1700074CPL	6-ML	0.8 %	-	-	-	-	-	-	-	-	-	-	99.2 %	11/6/99
Grey dirt					*NFM:*	, Misc. Part.								SS
													Asb/Points	8/1000
1700075CPL	7-FH1	0.2 %	-	-	-	-	-	-	-	-	-	-	99.8 %	11/6/99
Grey dirt					*NFM:*	, Misc. Part.								SS
													Asb/Points	2/1000

Samples received on: Friday, November 5, 1999

Authorized Signature

Scott Stotler, Geologist

Date Monday, November 8, 1999

RJ Lee Group, Inc.
Bay Area Lab

530 McCormick Street
San Leandro, CA 94577

Phone (510) 567-0480
Fax (510) 567-0488

Air Resources Board

Barbara Riordan, Chairman
P.O. Box 2815 · 2020 L Street · Sacramento, California 95812 · www.arb.ca.gov

Peter M. Rooney
Secretary for Environmental Protection

Pete Wilson
Governor

November 2, 1999

Steve Yata
RJ Lee Group
530 McCormick St.
San Leandro, CA 94577

Dear Mr. Yata:

Enclosed are 7 bulk samples for a modified ARB Test Method 435 (TM435) analysis. The samples have been crushed as required by TM435. I want a one thousand (1000) point count on each sample instead of the usual 400 point count required by TM435. I do not want any visualization techniques used. I talked to Ben Schiflebin and the cost per sample for a 24 hour turn around would be $75. Ben said, a preliminary report of the analysis would be FAX'd to ARB within the 24 hour period and the final report would be mailed within five working days. Please use the ARB Log # and the ARB sample # as the client's sample # in your tracking system.

Please fax the preliminary results to George Lew at (916) 322-2444. Send the final results along with the completed chain of custody form to:

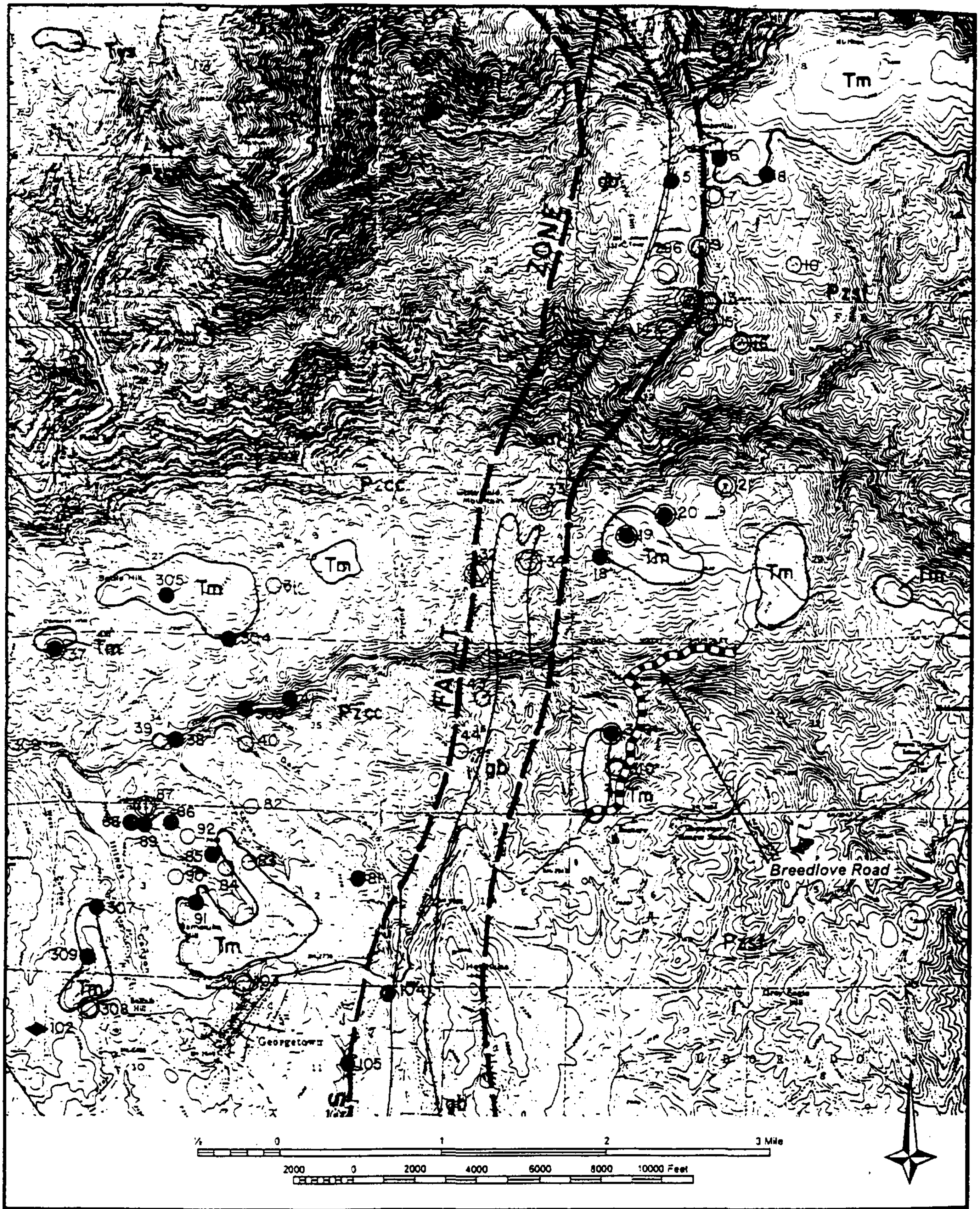
George Lew, Chief
Engineering and Laboratory Branch
Air Resources Board
P. O. Box 2815
600 North Market Blvd
Sacramento, CA 95814

If you have questions, please contact me at (916) 327-1502.

Sincerely,

James E. McCormack
Air Resources Engineer
Monitoring and Laboratory Division

California Environmental Protection Agency



YOUNGDAHL & ASSOCIATES, INC.
GEOTECHNICAL, ENVIRONMENTAL & CONSTRUCTION LAB

Project No.: 99292	UNPAVED ROADS GEOLOGIC RECONNAISSANCE	FIGURE
September 1999	**Breedlove Road - Section 30** El Dorado County, California	**6**

CHAIN OF CUSTODY
CALIFORNIA AIR RESOURCES BOARD
MONITORING & LABORATORY DIVISION
ENGINEERING & LABORATORY BRANCH
P O Box 2815, Sacramento, CA 95812

ASBESTOS SOIL SAMPLING
EL DORADO COUNTY
OCTOBER, 1999

SAMPLE RECORD

Job #: C-99-103   Date: / /99

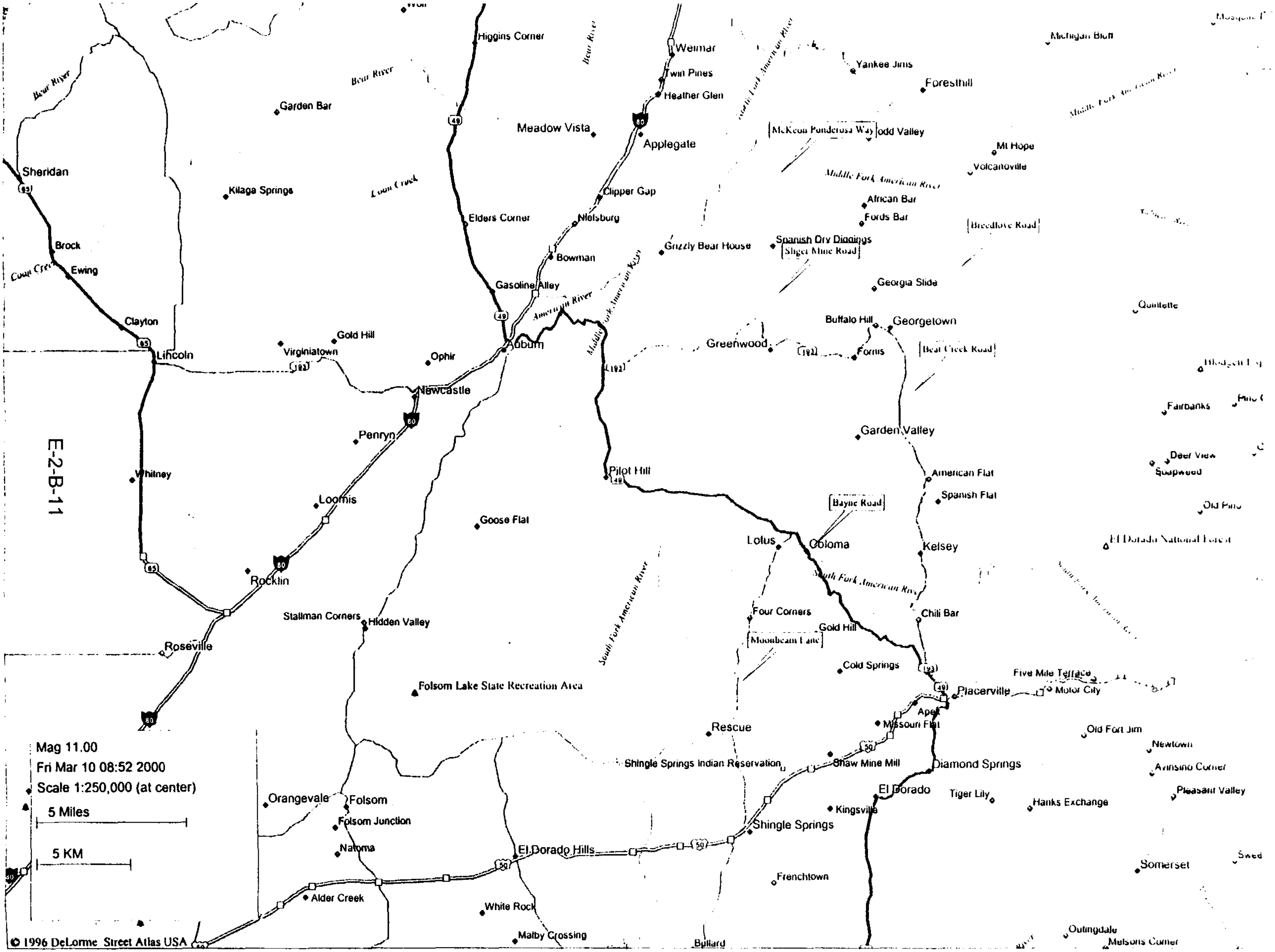
Log numbers: 1 - 6

ACTION	DATE	TIME	INITIALS GIVEN BY	INITIALS TAKEN BY	METHOD OF STORAGE
Sample Collected	10/24/99	0800 - 1500	ORL		BUCKET
Transfer			Oscar Lopez		Bucket
Transfer	11/3/99	0730	Oscar Lopez		Buckets
Transfer	11/4/99	0655			Bucket
Transfer	11/4/99	1300			Bucket/BAG
Transfer	11/4/99	1500		UK	Bag
Transfer					

LOG #	ID #	✓	DESCRIPTION
1	BR-1		BAYNES RD.
2	BR-2		BAYNES RD.
3	BR		BREEDLOVE RD.
4	BCR		BEAR CREEK RD.
5	SMR		SLIGER MINE RD.
6	ML		MOONBEAM LANE
7	FH1		McGUEN/Ponderosa Rd.
			Seven bags sealed cat Chemax lab

RETURN THIS FORM TO: Oscar R. Lopez (916) 323-1161

Attachment III
Map Showing Approximate Location of Unpaved Roads


Higgins Corner
Weimar
Michigan Bluff
Bear River
Twin Pines
Yankee Jims
Heather Glen
Foresthill
Garden Bar
Middle Fork American River
Meadow Vista
Applegate
McKeon Ponderosa Way
Todd Valley
Mt Hope
Sheridan
Kilaga Springs
Coon Creek
Volcanoville
Clipper Gap
African Bar
Elders Corner
Nielsburg
Fords Bar
Breedlove Road
Brock
Grizzly Bear House
Spanish Dry Diggings
Shiger Mine Road
Bowman
Ewing
Georgia Slide
Gasoline Alley
American River
Quintette
Clayton
Buffalo Hill
Georgetown
Gold Hill
Virginiatown
Greenwood
Fornis
Bear Creek Road
Lincoln
Ophir
Auburn
Newcastle
Fairbanks
Penryn
Garden Valley
E-2-B-11
Deer View
Soapweed
Whitney
Pilot Hill
American Flat
Loomis
Spanish Flat
Goose Flat
Bayne Road
Old Pino
Lotus
Coloma
Kelsey
El Dorado National Forest
Rocklin
South Fork American River
Four Corners
Chili Bar
Stallman Corners
Hidden Valley
Gold Hill
Moonbeam Lane
Roseville
Cold Springs
Five Mile Terrace
Folsom Lake State Recreation Area
Placerville
Motor City
Apex
Rescue
Missouri Flat
Old Fort Jim
Newtown
Mag 11.00
Fri Mar 10 08:52 2000
Scale 1:250,000 (at center)
5 Miles
5 KM
Shingle Springs Indian Reservation
Shaw Mine Mill
Diamond Springs
Avansino Corner
El Dorado
Tiger Lily
Pleasant Valley
Orangevale
Folsom
Hanks Exchange
Kingsville
Folsom Junction
Shingle Springs
Natoma
El Dorado Hills
Somerset
Sweet
Frenchtown
Alder Creek
White Rock
Outingdale
Malby Crossing
Bullard
Melsons Corner
© 1996 DeLorme Street Atlas USA
65
80
49
193
50

Attachment IV
Report on Unpaved County Roads in El Dorado County

YOUNGDAHL
& ASSOCIATES INC.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS TESTING

OCT 27 3 24 PM '99
BOARD OF SUPERVISORS
EL DORADO COUNTY

El Dorado County
Department of Transportation
2850 Fairlane Court
Placerville, CA 95667

Project No. 99292
13 September 1999

Attention: Mr. Keith Harvey

Subject: **SECTIONS OF EL DORADO COUNTY UNPAVED ROADS**
Geologic Reconnaissance for Potential Asbestos Conditions
Letter Report

Reference: Draft Map of Areas Within El Dorado County Requiring Investigation/Evaluation for the Presence of Naturally Occurring Asbestiform Minerals, prepared by SAGE Environmental Science Committee, July 1999.

Dear Mr. Harvey:

At your request, Youngdahl & Associates, Inc. has performed a geologic reconnaissance of 14 sections of unpaved El Dorado County roads. The sections were selected by the El Dorado County Department of Transportation (D.O.T.)on the basis of the referenced map. The referenced map utilizes sections of USGS 7.5 minute quadrangles to identify a section as either not likely to contain asbestos or to identify sections that should be further evaluated. Those areas of unsurfaced roads that fall outside of the areas of further evaluation identified on the referenced map are considered unlikely to contain significant quantities of naturally occurring asbestos. Many of these roads are completely unsurfaced, relying on native soils/rock to provide a road bed.

The primary focus of our geologic reconnaissance was to identify sections of road that, based on the types of rock present, have a potential to contain naturally occurring asbestos and may require additional investigation/remediation. Our reconnaissance required us to observe the bare road and/or road cuts in sections of unpaved roads. We did not evaluate paved sections of road. A secondary focus was to observe any aggregate materials used to surface roads within these sections to check for the use of serpentine aggregates. This required a periodic visual examination of the aggregates. The following roads were evaluated:

1) South Shingle Road, Section 16;
2) Russell Hollow Road, Section 11;
3) Goose Flat Road, Section 15;
4) An unnamed loop of Pleasant Valley Road, Section 29;
5) Cosumnes Mine Road, Sections 4 and 9;
6) Indian Diggins Road, Sections 17 and 18;
7) Farnham Ridge Road, Sections 25, 30, 29;

RECEIVED
Oct 27 3 25 PM '99
BOARD OF SUPERVISORS
EL DORADO COUNTY

1234 GLENHAVEN COURT ■ EL DORADO HILLS, CA 95762
PHONE (916) 933-0633 FAX (916) 933-6482

8) Mameluke Hill Road near Georgia Slide Road, Section 2;
9) Breedlove Road, Section 30;
10) Bear Creek Road, Sections 19 and 30;
11) Bayne Road, Sections 14, 17, 21;
12) Mosquito Road, Section 14;
13) Mt. Murphy Road, Sections 5, 8, 17; and
14) Park Creek Road, Section 3.

Of the above listed roads, Russell Hollow Road, the unnamed loop of Pleasant Valley Road, Mameluke Hill Road, and Mosquito Road were found to be surfaced with asphalt and were thus not further evaluated.

South Shingle Road, County Road No. 17, Section 16

South Shingle Road passes through the community of Latrobe and heads westerly across the Sacramento County Line. This stretch of the road passes over an area mapped to contain Jurassic Copper Hills Volcanics and gabbroic rocks. In Youngdahl & Associates, Inc. experience, this area also contains small bands of the Jurassic Salt Springs Slate.

The evaluation of the stretch of South Shingle Road west of Latrobe Road began with the measuring of mileage starting at the intersection of South Shingle and Latrobe Roads. The first roadcuts, 0.6 miles west of Latrobe Road but still in the paved section, exposed moderately to highly weathered Copper Hill Volcanics with very closely spaced fractures, probably a metamorphosed subaqueous tuff. The paved section ended 0.65 miles from Latrobe Road. The unpaved road appeared to surfaced with AB (aggregate base) type aggregate. No serpentine or asbestos was observed. A quartz vein was observed at mile 1.05, about 20 feet east of milepost 2.32. The road base appeared to have been oiled at 1.1 miles from Latrobe Road. By mile 1.5, the Copper Hill Volcanics in the vicinity of the road were noted to exhibit "tombstone" outcrops, typical of old submarine lava flows. At 1.8 miles, occasional serpentine fragments was observed to be mixed with the other gravel in the road base. At 2.0 miles the aggregate used on the road surface became very sparse. At mile 2.8 and the end of the stretch of road to be investigated, a large boulder of imported serpentine was observed at mile post 0.57. No asbestos was observed on this section of South Shingle Road. Small amounts of serpentine was observed to be mixed into the aggregate on this road.

Goose Flat Road, County Road 42, Section 15

Goose Flat road is a very lightly used road that connects Rattlesnake Bar Road to Folsom Lake near an idle limestone mine. The road used to be a section of Rattesnake Bar Road that led to a bridge that crossed the North Fork of the American River. The road was once paved but has now deteriorated to the point where the road now has to be partially surfaced with aggregate.

The rocks in this area include Jurassic Copper Hill Volcanics with limestone deposits and probable thin beds of Salt Springs Slate. The road passes very close to the west side of the mapped West Branch of the Bear Mountains Fault Zone. West of this road, ultramafic deposits associated with chromite deposits are present. In Youngdahl & Associates, Inc. opinion, this stretch of road may lie within the West Branch of the Bear Mountains Fault Zone.

Starting the mileage measurement at the intersection of Rattlesnake Bar Road and Goose Flat Road, the road aggregate appeared to be a combination of metavolcanic rock and limestone without any serpentine or asbestos. At mile 0.05, an idle limestone quarry was observed on the east side of the road. At mile 0.08, an outcrop of metavolcanics/metasediments striking due north and dipping 70 degrees to the east was observed. By the time the end of the road was reached at mile 0.25 at a rock barrier, no serpentine or asbestos was observed either in the road cuts or in the aggregate.

Cosumnes Mine Road, County Road 877, Sections 4 and 9

Cosumnes Mine Road connects String Canyon Road with Sciaroni Road northwest of the community of Grizzly Flat. The road passes through Mesozoic granitic rocks and near Paleozoic Shoo-fly metasediments. The road passes through sections 4 and 9 which are identified on the referenced map as requiring further evaluation for asbestos.

The section that passes through Section 9 is paved. The pavement ends about 125 feet north of private Bevearly Hills Road near 5010 Cosumnes Mine Road. In Section 4. The initial surfacing material was noted to be crushed river gravel and crushed quarried rock. No serpentine or asbestos was observed. Decomposed granite was visible in road cuts near this point. Cosumnes Mine Road enters national forest land 0.4 miles from the end of pavement. At 1.0 mile a gabbroic rock outcrop was observed in a road cut. No serpentine or asbestos was observed in the road cuts, the base of the road, or in the aggregate used to surface the road.

Indian Diggins Road, County Road 92, Sections 17 and 18

Indian Diggins Road passes south and west off of Omo Ranch Road near the community of Omo Ranch. The road serves an area that once included hard rock and placer gold mines. Virtually all of the Section 17 portion of the road is mapped as crossing through Tertiary Mehrten volcaniclastics. (mudflows). The portion that crosses Section 18 passes over Paleozoic Shoo-fly metasedimentary rocks.

For the purposes of our reconnaissance, the mileage was started where the pavement ends, right at the intersection with Omo Ranch Road. At the start of the road, no rock exposures were visible and the road was observed to be surfaced with rounded river gravels and newer crushed rock without serpentine or asbestos. No rock exposures were observed until about 0.7 miles when volcanic conglomerate was found in a road cut. At 1.4 miles from the intersection an exposure of light gray volcanic ash with cobble clasts was observed. At this point the use of aggregate road base ended and the road was observed to be surfaced with native soils. The county road appeared to end at mile 1.9, becoming a logging road/trail. No serpentine or asbestos was observed in the cuts, the base of the road, or in the aggregates used on the road.

Farnham Ridge Road, County Road 93, Sections 25, 30, and 29

Farnham Ridge Road connects Bridgeport School Road with scattered residences and private logging lands. This road crosses a mixture of Tertiary Mehrten Mudflows, Paleozoic Calaveras Formation metasediments and Palezoic Shoo-fly metasedimentary rocks, which are separated by from each other by the Shoo-fly thrust fault.

Our reconnaissance started at the intersection with Bridgeport School Road. The geology of this area is mapped as Tertiary Mehrten Mudflow. The road appeared to be surfaced with a minimal amount of limestone aggregate base rock. One mile down the road, a small amount of unmapped granitic rocks was evidenced by decomposed granite soils with mafic xenolith core stones. At 1.5 miles down the road, the use of aggregate increases on the road, being mostly rounded gravels and not limestone. At 3.8 miles down the road the use of aggregate ended, with the road being surfaced with native soils. At 4.4 miles down the road, the use of limestone aggregate was observed to resume. Rock outcrops of Mehrten mudflows were observed 4.5 miles down Farnham Ridge Road. The use of limestone aggregate road base was observed to end at mile 5.0. The end of the road was reached at a gate at mile 5.3.

Rock exposures were severely limited. Although Farnham Ridge Road is mapped as crossing the Paleozoic Calaveras and Paleozoic Shoe-fly formations, no outcrops were visible. The Shoo-fly thrust fault was not visible. No serpentine or asbestos was observed along this stretch of road or within the aggregate used to surface the road.

Breedlove Road, County Road 112, Section 30

Breedlove Road provides access to residences and the El Dorado National Forrest north of Wentworth Springs Road, east of the community of Georgetown. This road is mapped as passing over Paleozoic Shoo-fly metasediments approximately ½ to 1 mile east of the Melones Fault Zone and the Shoo-fly Thrust Fault.

For the purposes of this evaluation, mileage measurements started at the intersection with Wentworth Springs Road. Breedlove Road was observed to be paved until mile 0.2. At this point, no rock exposures were present. The road was observed to be surfaced with a mixed crushed aggregate containing limestone, unknown metamorphic rocks, and some serpentine. No asbestos was visible. By 0.5 miles down the road, the aggregate was observed to very sparse and the road surfaced with native soils. An increase in aggregate at 0.95 miles did not appear to contain serpentine or asbestos. Road cuts in this area were observed to contain weathered metagraywacke of the Shoo-fly Formation with foliations striking northwest and dipping vertically. At mile 1.8, aggregate was again observed to be in use on the road and contained a trace of serpentine. The end of the road was reached at mile 2.2.

No asbestos or native serpentine was observed along Breedlove Road. Small amounts of serpentine were observed mixed into aggregate used on the road surface.

Bear Creek Road, County Road 46, Sections 19 and 30

Bear Creek Road serves an area extending from the south end of Georgetown to Spanish Flat, northeast of the community of Kelsey. Most of this road is surfaced with asphalt. One section is unsurfaced and passes over Paleozoic Shoe-fly metasediments, Paleozoic metamorphic rocks of the Melones Fault Zone, and the Shoo-fly Thrust Fault.

For the purposes of this reconnaissance, mileage measurements started at the intersection with Meadow Brook Road in a paved stretch. The pavement was observed to end 0.8 miles south of this intersection. Exposures in road cuts at this point appeared to be weathered Shoo-fly graywacke. The road was observed to be surfaced with aggregate that, based on visual observations, contains up to 5% serpentine. A spot check of the road aggregate at mile 1.2 did not find any serpentine or asbestos. A check of the aggregate at the intersection of Branch Way visually identified scattered pieces of serpentine (near paddle marker 3.20). A check of the aggregate at mile 2.3 (paddle marker 2.62) noted scattered pieces of serpentine. The pavement started again at mile 2.5.

Rock exposures along the unpaved stretch of Bear Creek Road were very poor. No asbestos or native serpentine was observed along the unpaved section of this road. Some scattered serpentine fragments were observed to be mixed into the road aggregate.

Bayne Road, County Road 55, Sections 14, 17, and 21

Bayne Road connects the communities of Coloma and Kelsey. Portions of this road are paved and crosses over Mesozoic Granitics, Jurassic Mariposa metasediments, Jurassic Logtown Ridge metavolcanics and metesediments, the West Branch of the Melones Fault Zone, and the Paleozoic Calaveras metasediments.

For the purpose of this evaluation, mileage measurements started near the end of the pavement on the west end of the road near the intersection with private Serenity Lane. The aggregate used at the start of the unpaved section appeared to be comprised of dark gray metasediments or metavolcanics. The first road cut exposures were noted at mile 0.3 and consisted of massive metasediments with some carbonate inclusions. A short paved section of road was observed at mile 0.3 to mile 0.4. A small patch of serpentine aggregate was observed at mile 2.3. At mile 2.8 (paddle marker 1.22) weathered slates were visible in road cuts. The pavement began again at mile 3.0.

No native asbestos or serpentine was observed along Bayne Road. A very small patch of serpentine aggregate was observed.

Mt. Murphy Road, County Road 75, Sections 5, 8, and 17

Mt. Murphy Road is a historic route that connects the communities of Coloma and Garden Valley. The portion of the road that ascends from Coloma up Mt. Murphy has sections that are not currently passable by low ground clearance vehicles and thus appears to have only limited use.

Mt. Murphy Road crosses over Mesozoic granitic rocks, Jurassic Mariposa metasediments, and ultramafic rocks associated with chromite mining and serpentine aggregate mining.

The mileage measurements for our reconnaissance was started at the intersection with Carver Road in Coloma. Mt. Murphy Road starts off in granitic rocks and weathered decomposed granitic soils with an aggregate base of rounded and crushed stream rock without any visible serpentine. At mile 0.5 massive contact metamorphic rock of gneiss was observed in road cuts. Outcrops at mile 0.7 consists of massive, very hard metasediments with common carbonate inclusions. Massive serpentine rock was observed in the road bed at mile 1.3. No serpentine aggregate was observed. The serpentine extended about 100 feet until a point at which the road became paved.

A short stretch of Mt. Murphy Road may be underlain by serpentine near the paved stretch where the road crosses a saddle between Mt. Murphy and Mt. Perry. No serpentine aggregate or asbestos was observed along the unpaved stretch.

Park Creek Road, County Road 88, Section 3

Park Creek Road forms a loop that runs from Sly Park Road southeast of the community of Pollock Pines, passes north of Jenkinson Lake, and connects to Morman Emigrant Trail East of the lake. This road is mapped as crossing Tertiary Mehrten Mudflows in the area north of Jenkinson Lake.

For measurement purposes, mileages were recorded starting at the intersection with Hazel Valley Road. No aggregate was observed to be used on this road. Rock exposures at miles 0.1 and 0.3 were observed to consist of mudflow conglomerates and pyroclastic flows. The end of the study section was reached by approximately mile 2.0. No serpentine or asbestos was observed in rock exposures on in use as road base.

Conclusions

None of the unpaved roads evaluated within the scope of this reconnaissance contained exposures of visible asbestos in either the road bed or in road cuts. No talc schist or other rocks frequently associated with fault zones were observed. A short section of Mt. Murphy Road may be underlain by serpentine, although no asbestos was visible in the limited exposures.

Some of the roads in the Georgetown-Kelsey area were observed to contain varying amounts of serpentine in the aggregate surfacing material. The State of California considers any aggregate surfacing material that contains at least 10% serpentine to be serpentine material and subject to the requirements of testing for asbestos in serpentine as specified in Title 17, California Code of Regulations, section 94147. A portion of Georgia Slide and one small patch on Bayne Road may meet this criteria. Aggregate material mixtures observed on Breedlove Road and Bear Creek Road might also meet this criteria. If testing documentation is available for the serpentine aggregate placed on these roads, then further evaluation would be unnecessary. Such determinations would require additional investigation and analyses.

If you have any questions regarding this geologic reconnaissance, please do not hesitate to contact us at (916) 933-0633.

Very truly yours,
Youngdahl & Associates, Inc.

David C. Sederquist

David C. Sederquist, C.E.G.
Project Geologist
CEG 2133 Expires 9/30/2000

Reviewed by:

Roy C. Kroll

ROY C. KROLL
No. 1328
EXPIRATION DATE 12-31-00

Roy C. Kroll, C.E.G.
Associate Engineering Geologist

Attachments: Geologic References
Figures 1 through 11 - Geologic Maps of Road Segments
Figures 12 through 19 - Photographs of Roads

Distribution: Four Copies to El Dorado County Department of Transportation

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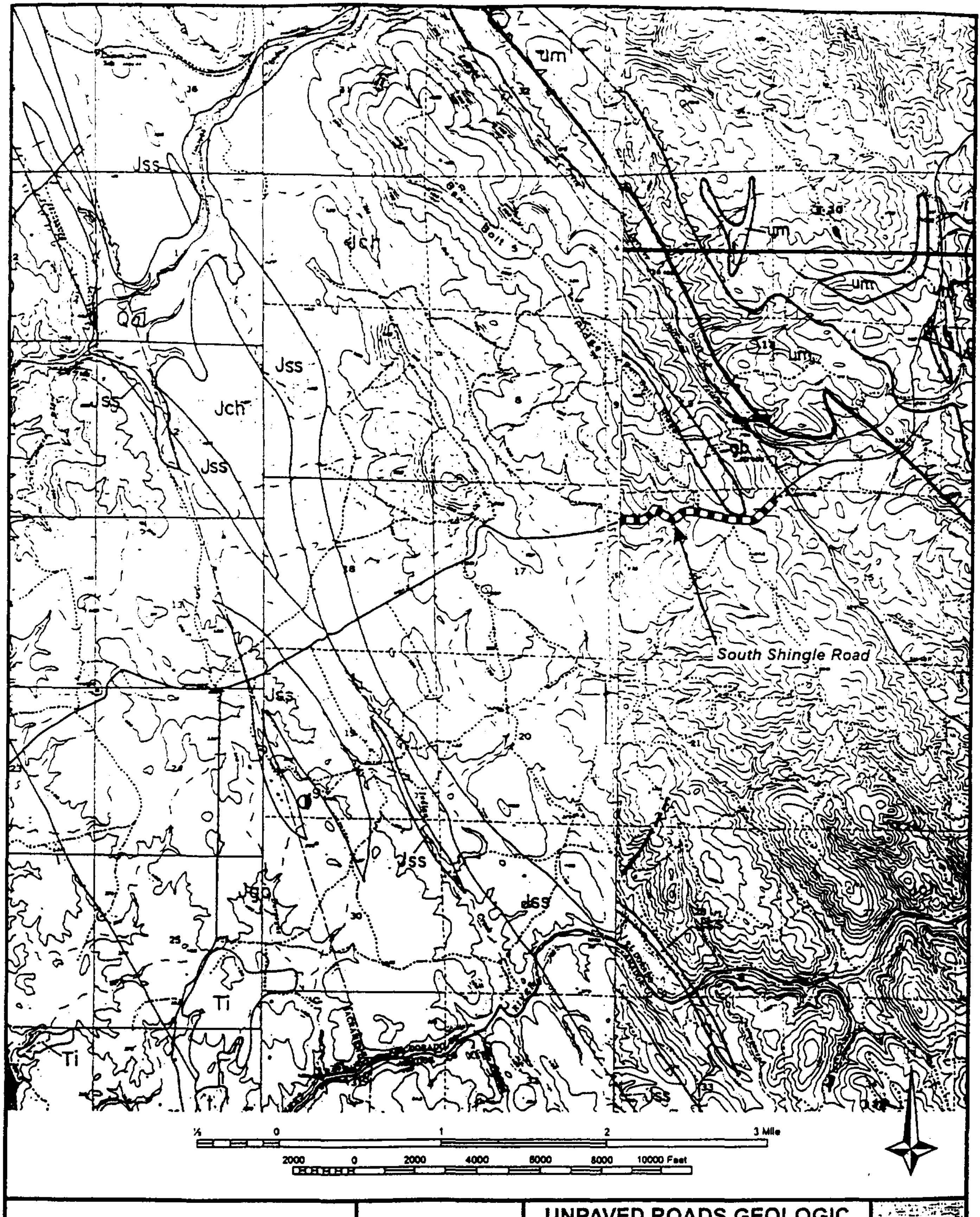

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GEOTECHNICAL, ENVIRONMENTAL & CONSTRUCTION LAB

Project No.: 99292

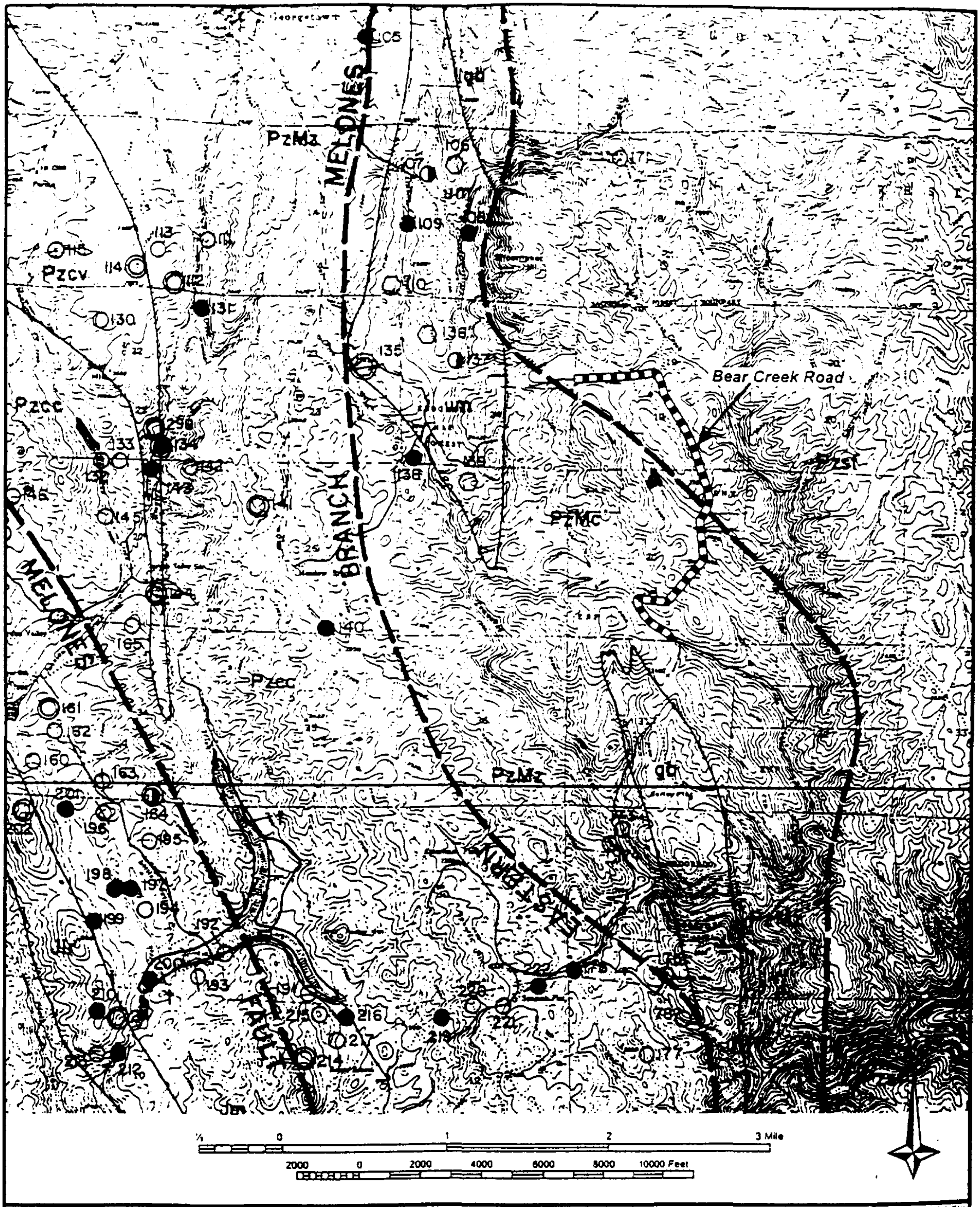
September 1999

UNPAVED ROADS GEOLOGIC RECONNAISSANCE

South Shingle Road - Section 16

El Dorado County, California

FIGURE 1



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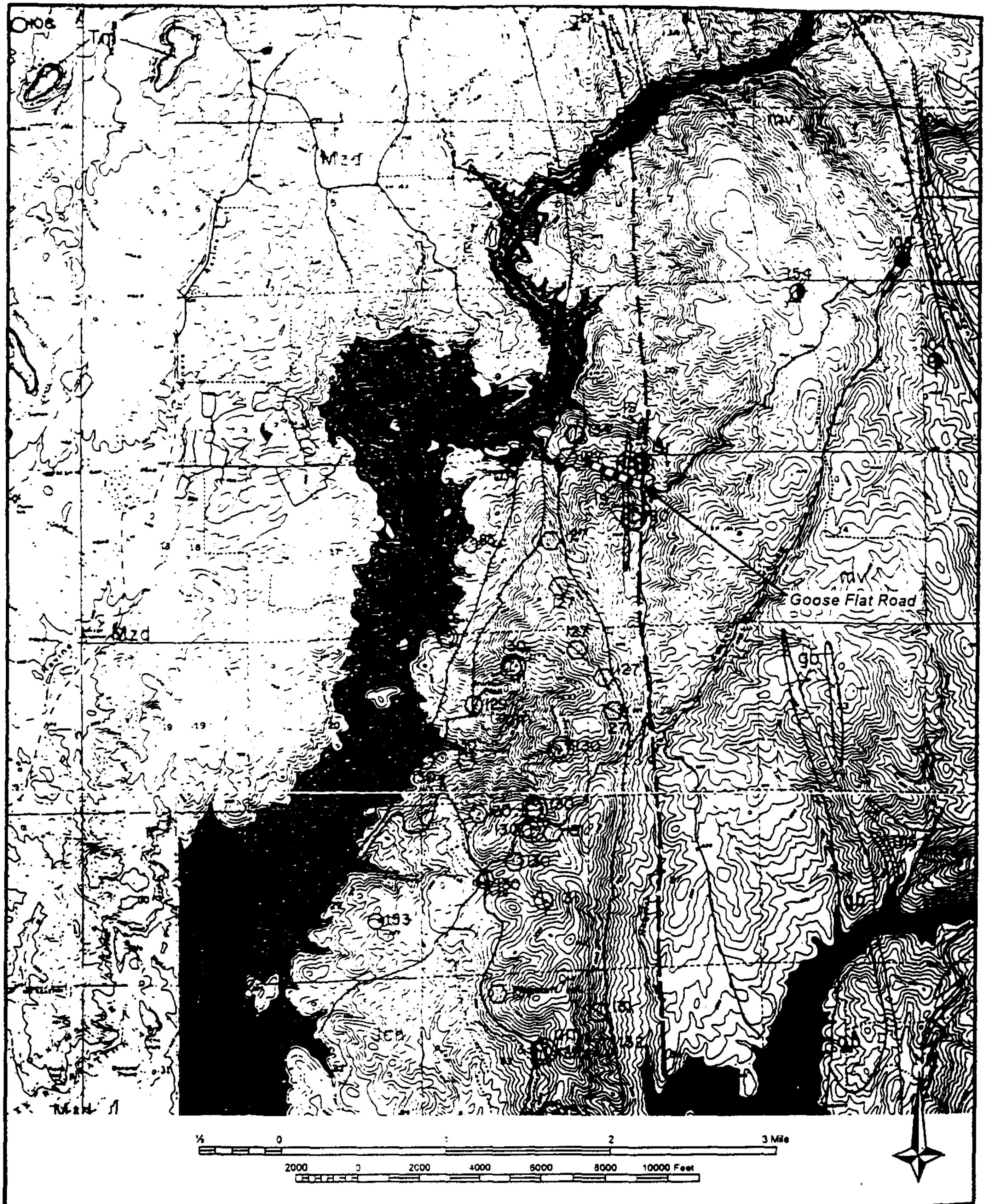
UNPAVED ROADS GEOLOGIC RECONNAISSANCE
Bear Creek Road - Sections 19 & 30
El Dorado County, California

FIGURE 7



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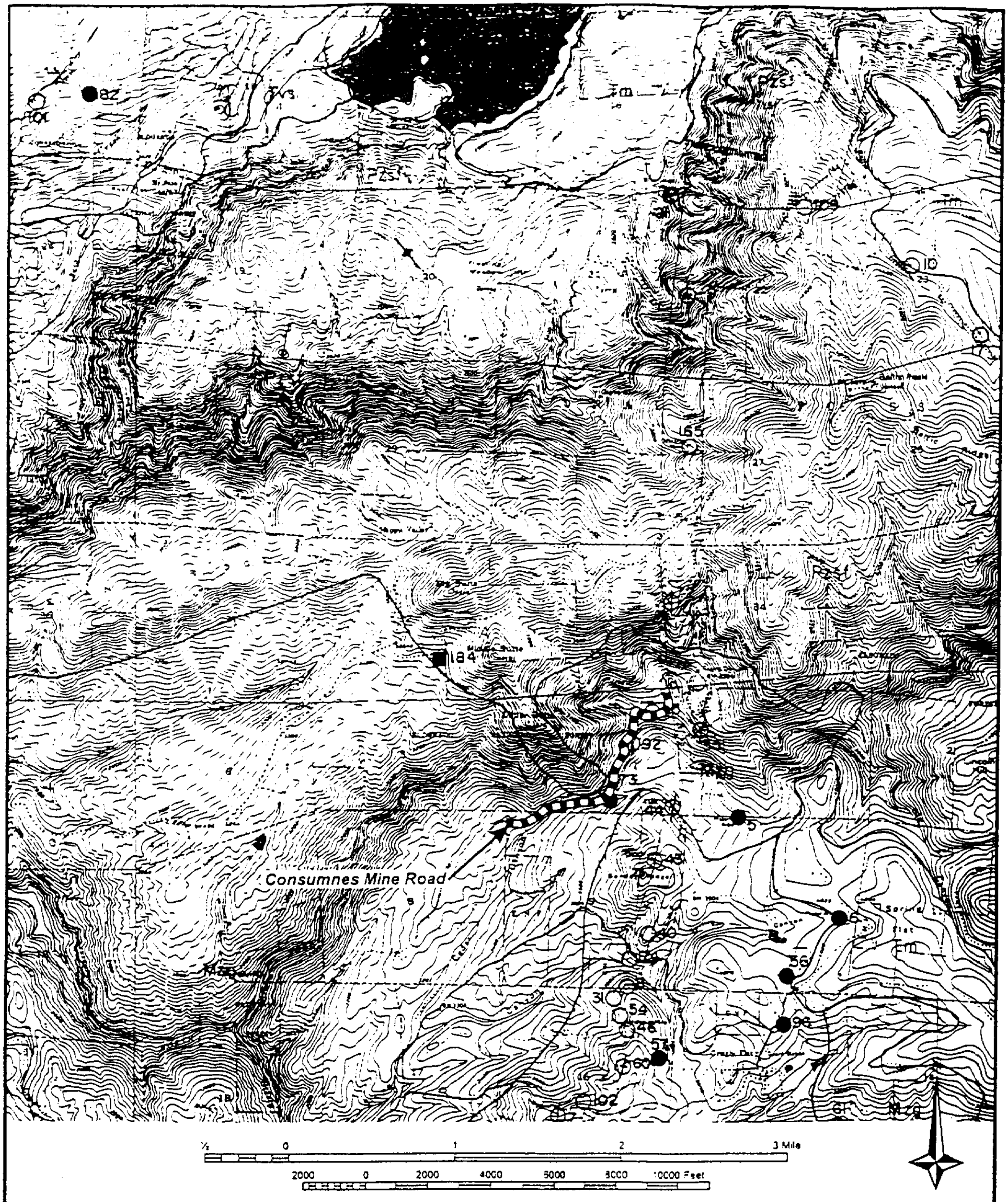
Goose Flat Road - Section 15
El Dorado County, California

FIGURE 2



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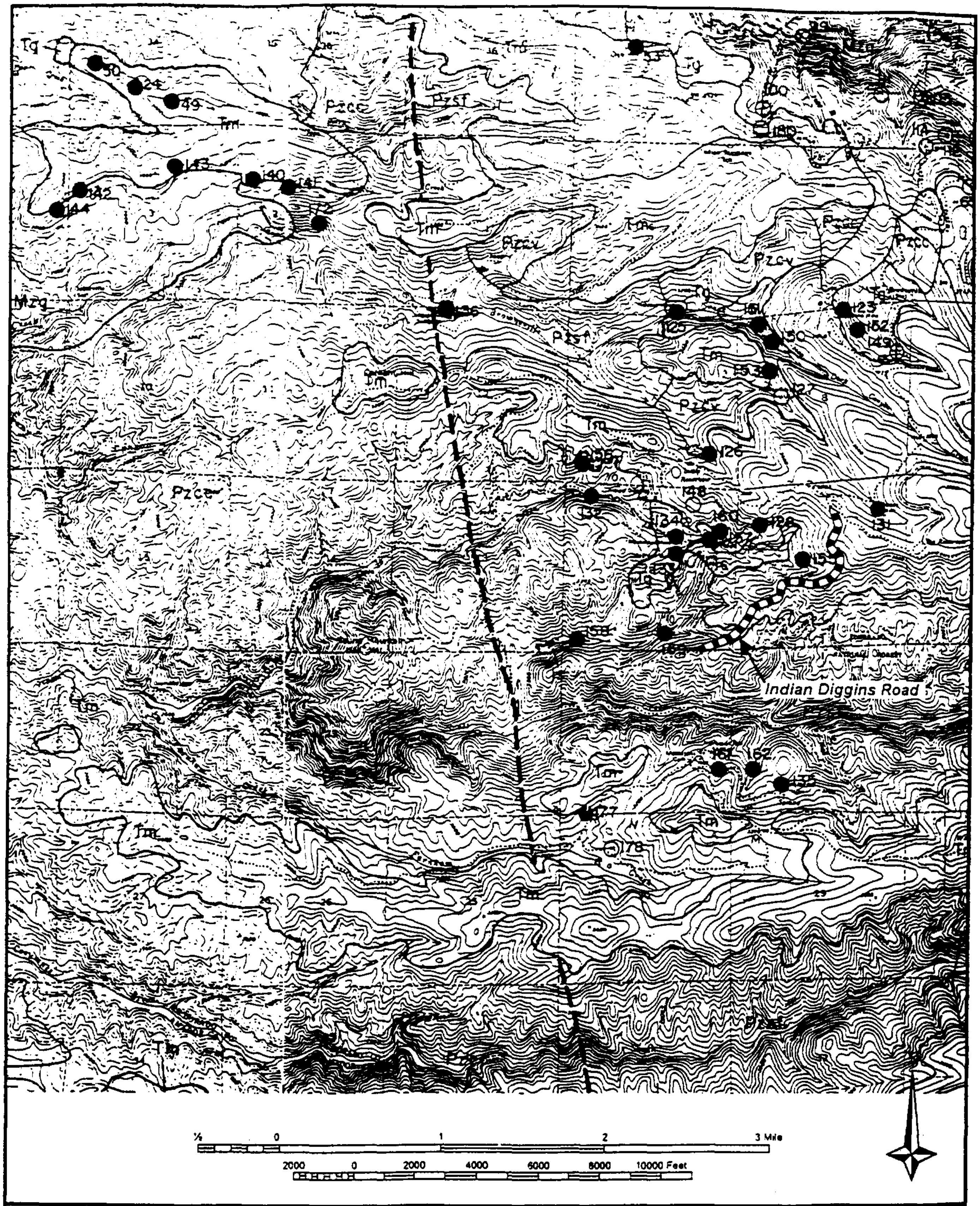
UNPAVED ROADS GEOLOGIC RECONNAISSANCE

Cosumnes Mine Road - Sections 4 & 9
El Dorado County, California

FIGURE
3



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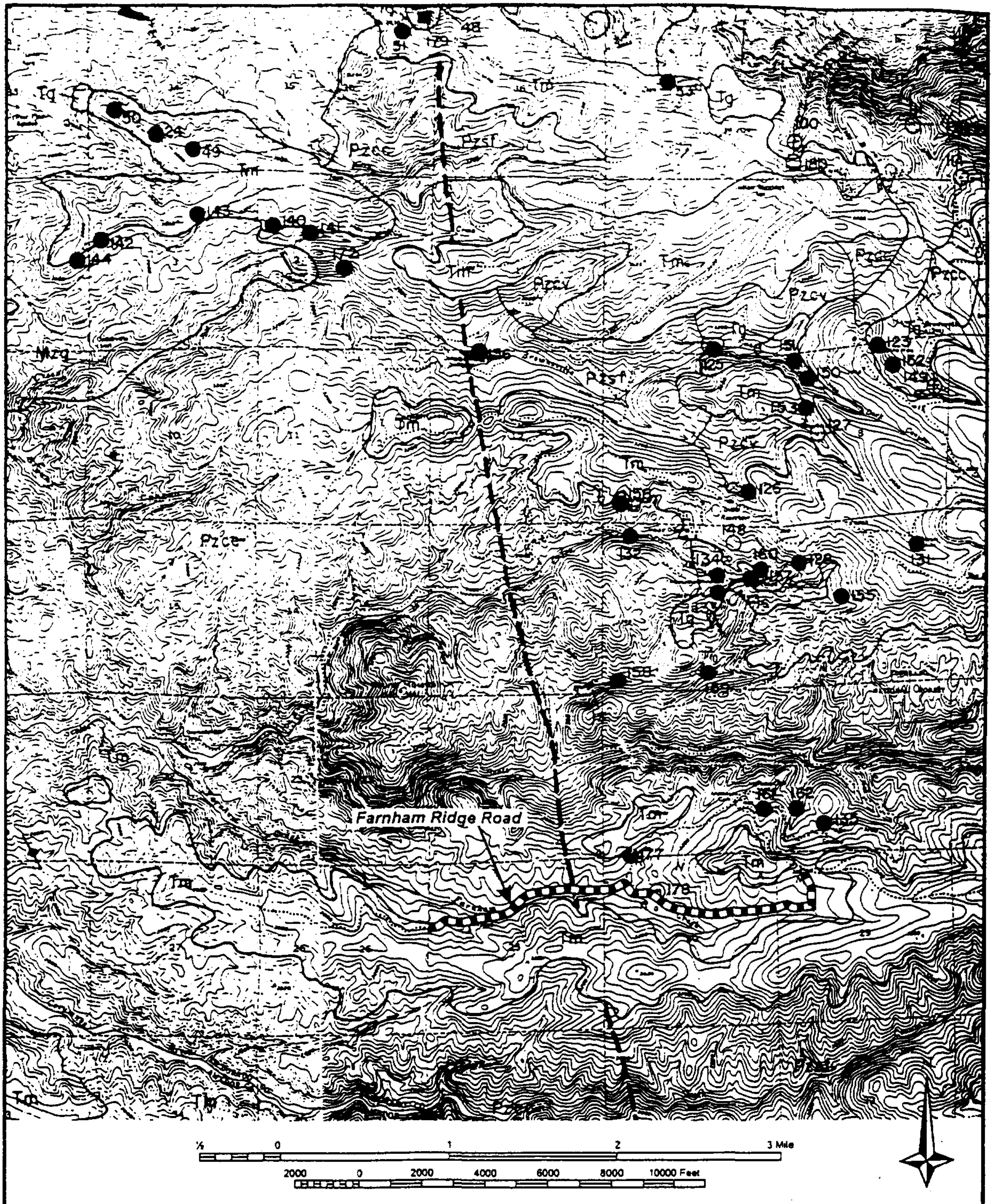
UNPAVED ROADS GEOLOGIC RECONNAISSANCE
Indian Diggins Road - Sections 17 & 18
El Dorado County, California

FIGURE 4



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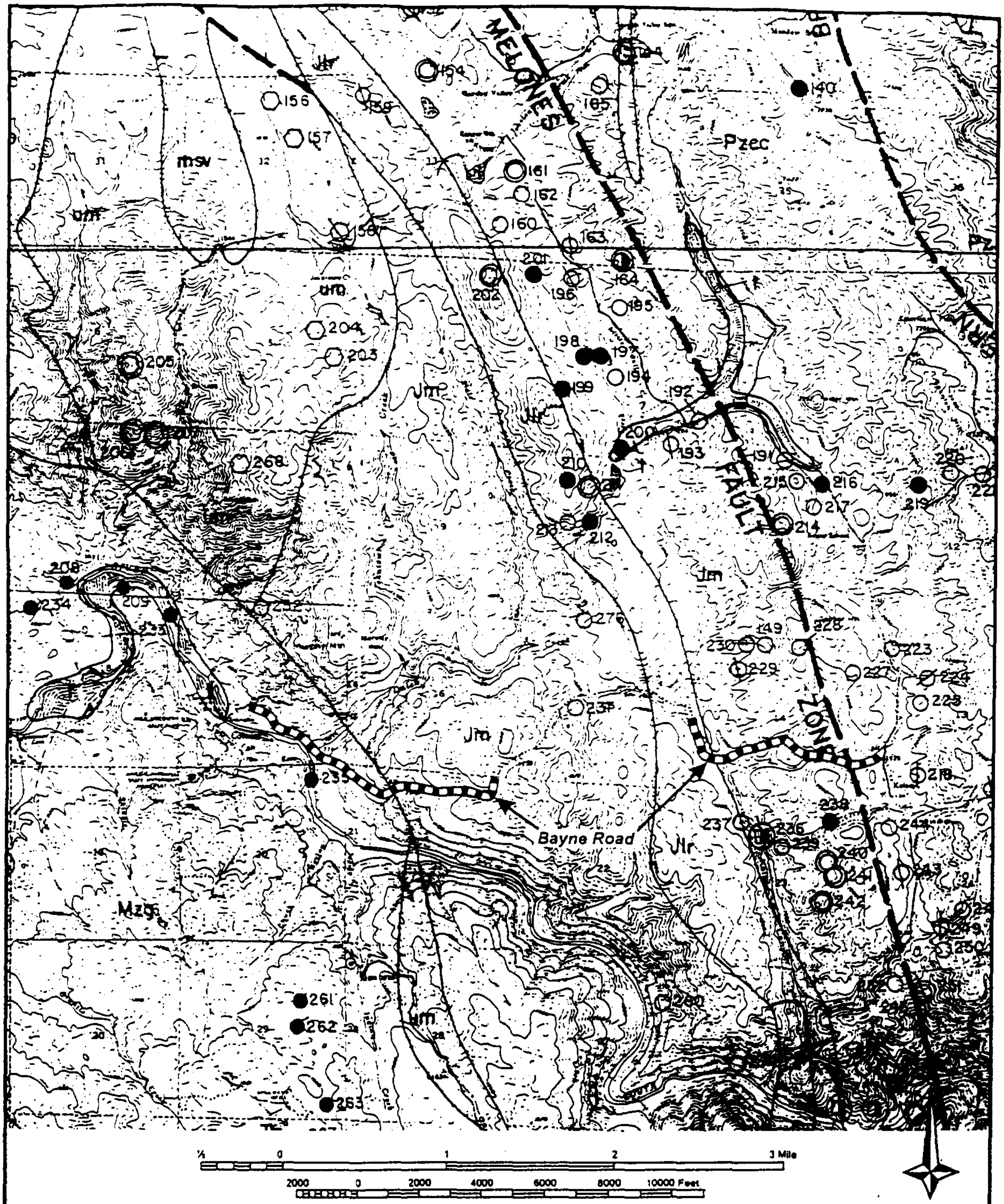
UNPAVED ROADS GEOLOGIC RECONNAISSANCE

Farnham Ridge Road - Sections 25, 30 & 29
El Dorado County, California

FIGURE 5



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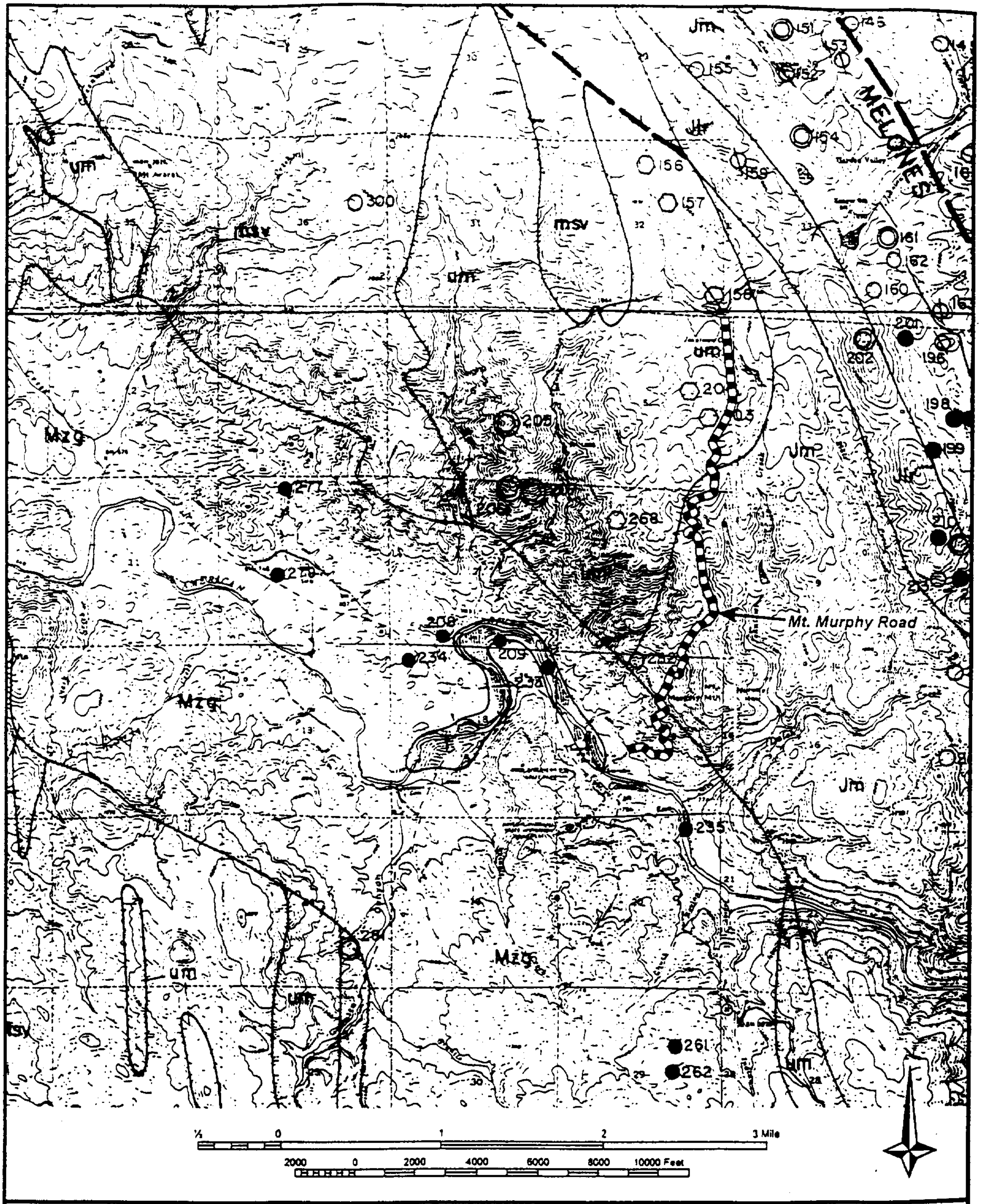
Bayne Road - Sections 14, 17 & 21

El Dorado County, California

FIGURE
8



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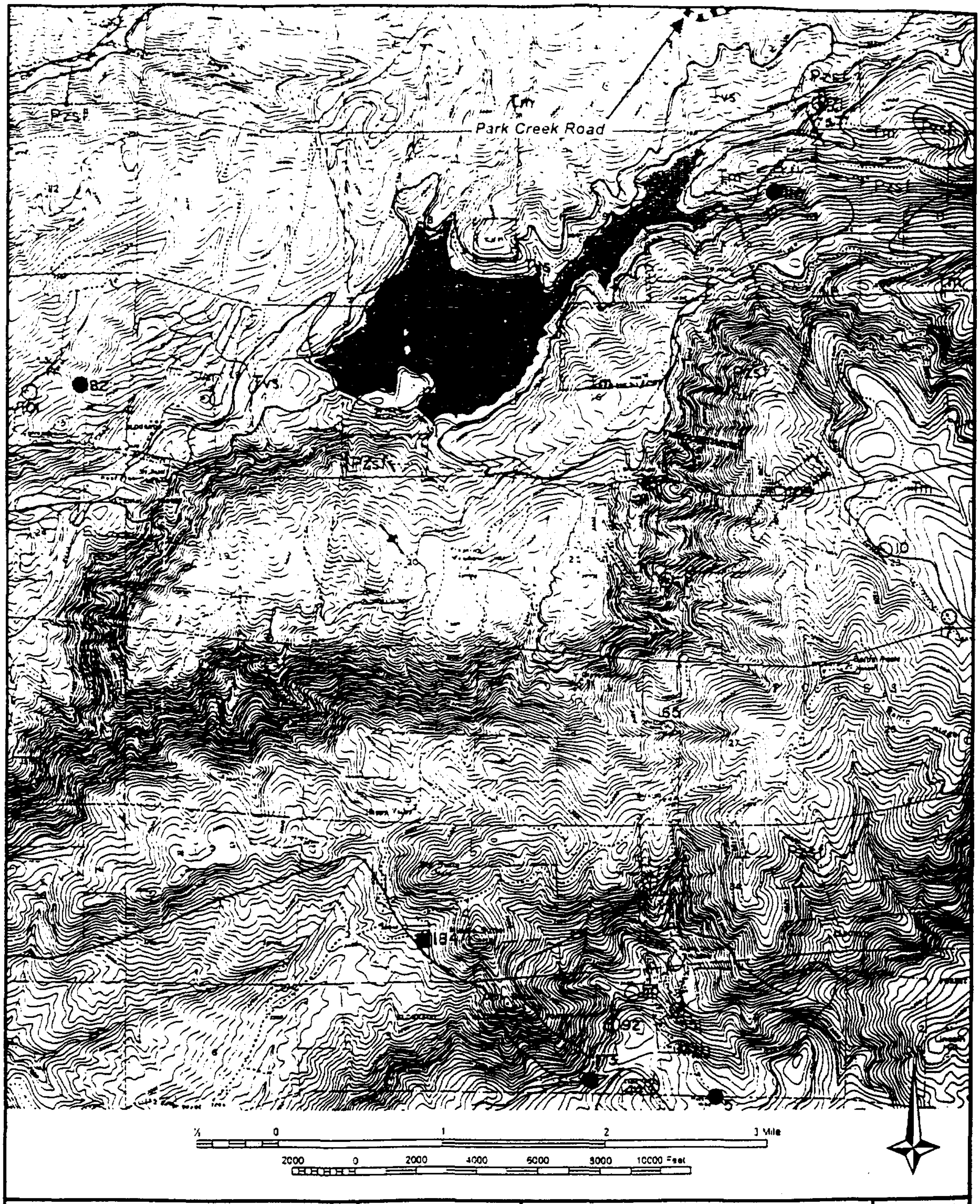
UNPAVED ROADS GEOLOGIC RECONNAISSANCE

Mt. Murphy Road - Sections 5, 8 & 17

El Dorado County, California

FIGURE 9



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UNPAVED ROADS GEOLOGIC RECONNAISSANCE

Park Creek Road - Section 3

El Dorado County, California

FIGURE 10

MINERAL DEPOSITS

⬡	Chromite
◑	Copper
○	Gold, Lode
●	Gold, Placer
◆	Manganese
■	Tungsten
◇	Limestone
◘	Slate
△	Clay
★	Silica
✚	Iron

MAP SYMBOLS

--——	Geologic Contact
--—	Fault
( )	Shear Zone
\ 80	Strike & Dip Of Foliation
●12	Mine & Prospect Location
·····	Quartz Vein
	Orientation Of Deposit
196◑	Mine Index Number

CENOZOIC	t	Dredge Tailings
	Q	Alluvium
	Qal	Quarternary Alluvium
	Tl	Alluvial Sand, Silt, & Conglomerate
	Tm	Mehrten Formation
	Tvd	Rhyodacite Domes
	Tvs	Valley Springs Formation
	Tg	Auriferous Gravels (Tertiary river channel deposits)
	Ti	Ione Formation
MESOZOIC	Kc	Chico Formation
	Jm	Mariposa Formation
	Jmb	Brower Creek Volcanics
	Jlr	Logtown Ridge Formation
	Mzg	Mesozoic Granitic Intrusive Rocks
	Mzd	Mesozoic Dioritic Intrusive Rocks
	Jch	Copper Hill Volcanics (Mesozoic Volcanic Island Arc Terrane)
	Jss	Salt Springs Slate
	Jgo	Gopher Ridge Volcanics
	msv	Metasedimentary Rocks (Melange Zone)
	ms	Metasedimentry Rocks (Melange Zone)
	ls	Limestone (Melange Zone)
	mv	Metavolcanic Rocks (Melange Zone)
	gb	Gabbro (Melange Zone)
	um	Ultramafic Rocks (Melange Zone)
	mvs	Undifferentiated Metavolcanic & Metasedimentary Rock (Melange Zone)
	Pzmz	Metamorphic Rocks
PALEOZOIC	Pzcc	Calaveras Complex (Metasedimentary Rocks - argillite & chert)
	Pzls	Calaveras Complex (Metasiltstone & Lenses of Carbonate Rock)
	Pzcv	Calaveras Complex (Metavolcanic Rocks)
	Pzct	Calaveras Complex (Talc)
	Pzsf	Shoofly Complex

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UNPAVED ROADS GEOLOGIC RECONNAISSANCE

Explanation & Legend For Maps

El Dorado County, California

Photo 1: South Shingle Road - Start of unpaved section on east end.

Photo 2: South Shingle Road - Typical aggregate road surface.

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UNPAVED ROADS GEOLOGIC
RECONNAISSANCE PHOTOS
South Shingle Road - Section 16
El Dorado County, California

FIGURE
12

Photo 3: Goose Flat Road - North end of road.

Photo 4: Goose Flat Road - Limestone Quarry.

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UNPAVED ROADS GEOLOGIC RECONNAISSANCE PHOTOS
Goose Flat Road - Section 15
El Dorado County, California

FIGURE
13

Photo 5: Cosumnes Mine Road - Start of unpaved road.

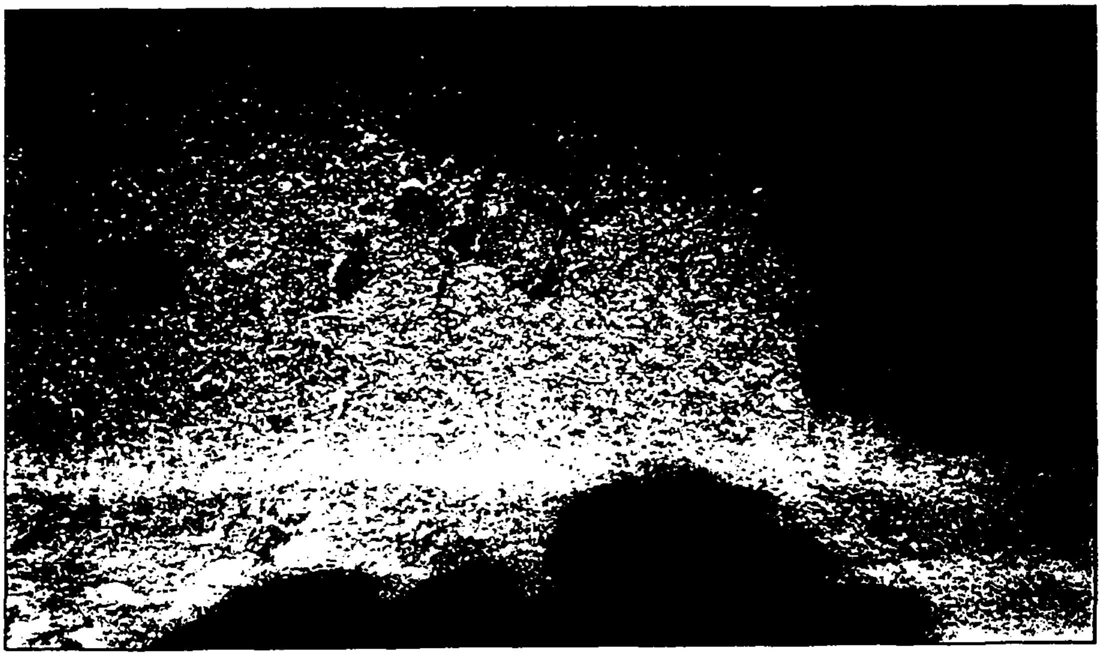

Photo 6: Cosumnes Mine Road - Typical exposure of granediorite.

YOUNGDAHL & ASSOCIATES, INC. GEOTECHNICAL ENVIRONMENTAL & CONSTRUCTION LAB	Project No.: 99292 September 1999	UNPAVED ROADS GEOLOGIC RECONNAISSANCE PHOTOS Cosumnes Mine Road - **Sections 4 & 9** El Dorado County, California	**FIGURE** **14**

Photo 7: Indian Diggins Road - Start of road at intersection with Omo Ranch Road.

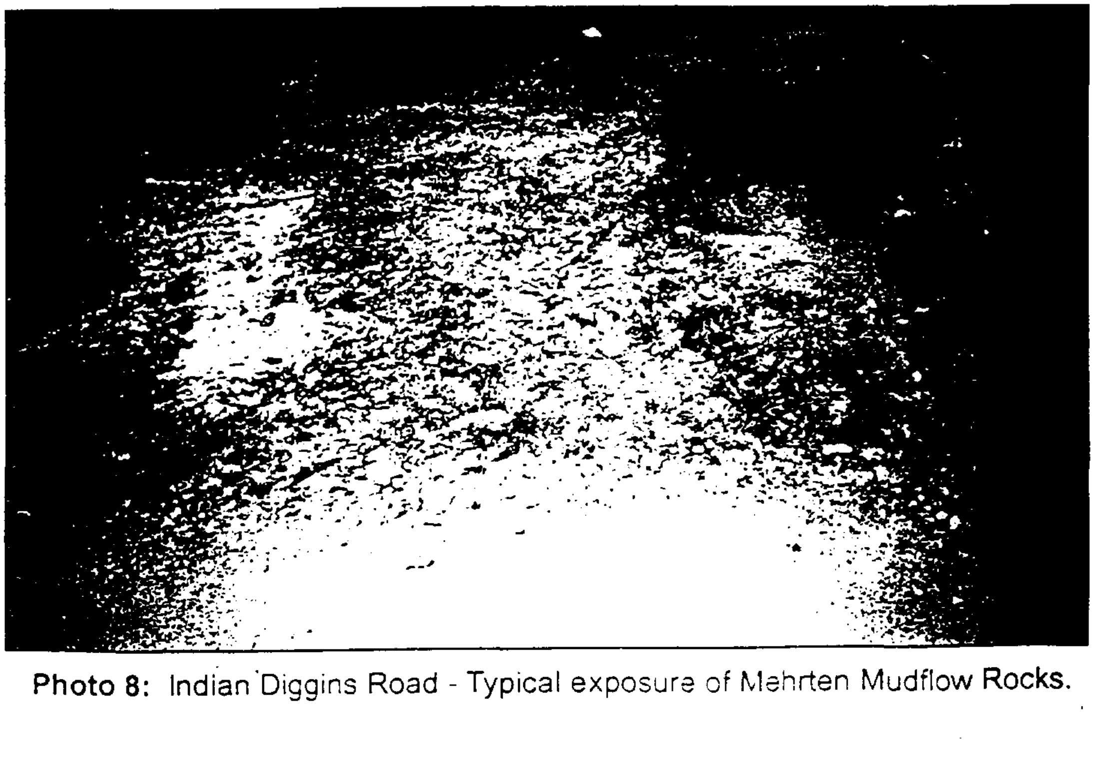

Photo 8: Indian Diggins Road - Typical exposure of Mehrten Mudflow Rocks.

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YOUNGDAHL & ASSOCIATES, INC.	Project No.: 99292 **September 1999**	UNPAVED ROADS GEOLOGIC RECONNAISSANCE PHOTOS **Indian Diggins Road - Sections 17 & 18** El Dorado County, California	**FIGURE** **15**

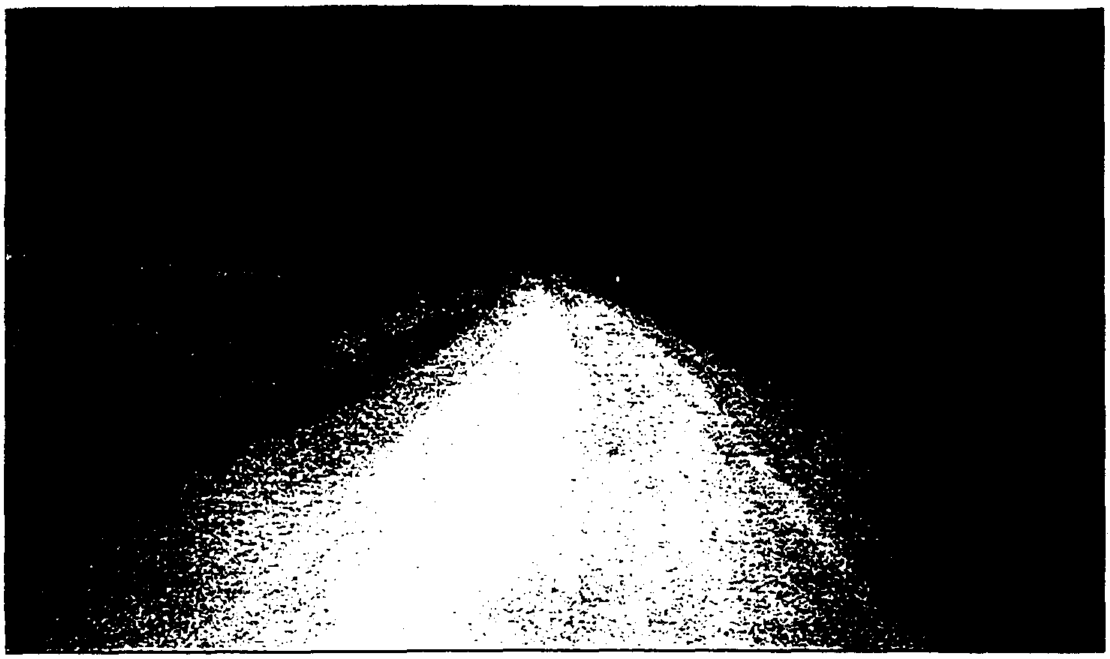

Photo 9: Farnham Ridge Road - Typical easterly view.

Photo 10: Farnham Ridge Road - Exposure of intrusive rocks.

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Photo 11: Breedlove Road - Top of road (looking south).

Photo 12: Breedlove Road - Bridge crossing (looking south).

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UNPAVED ROADS GEOLOGIC
RECONNAISSANCE PHOTOS
Breedlove Road - Section 30
El Dorado County, California

FIGURE
17

Photo 13: Bayne Road - Lower portion of unsurfaced portion.

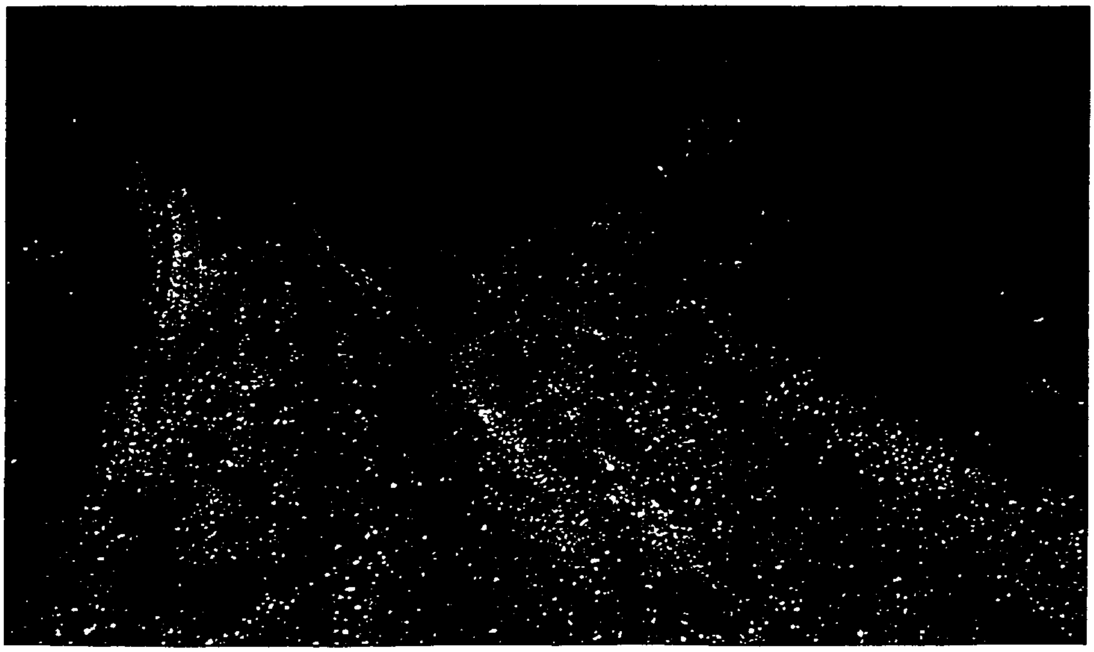

Photo 14: Bayne Road - Small area of serpentine aggregate.

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UNPAVED ROADS GEOLOGIC
RECONNAISSANCE PHOTOS
Bayne Road - Sections 14, 17 & 21
El Dorado County, California

FIGURE
18

Photo 15: Mt. Murphy Road - Top of unsurfaced portion.

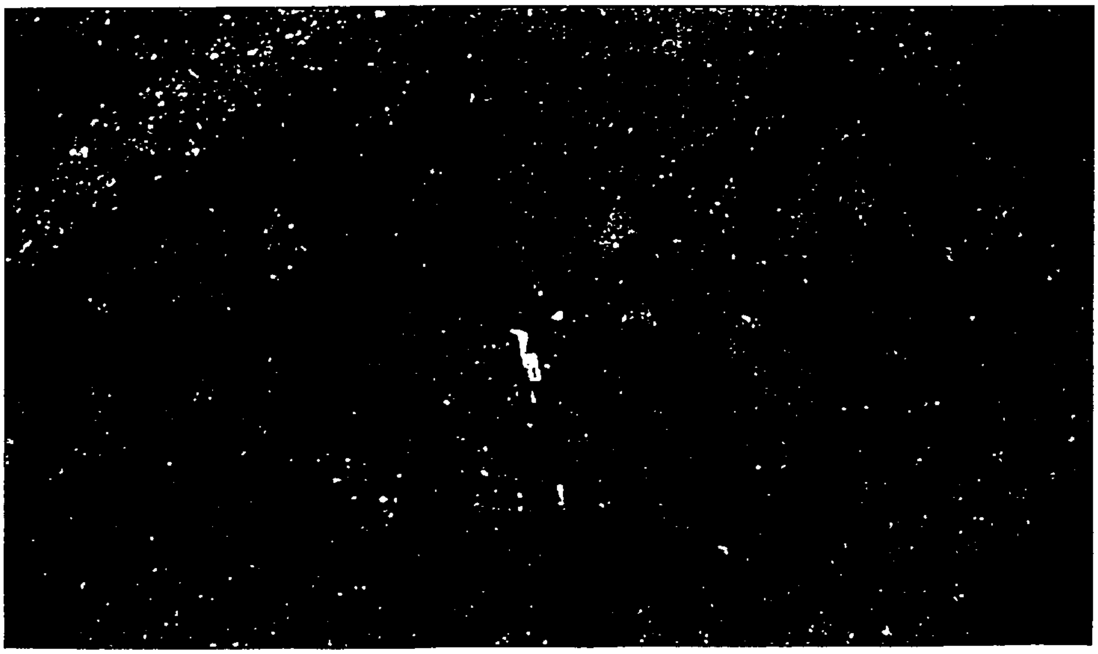

Photo 16: Mt. Murphy Road - Serpentine rock in base of road.

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September 1999

UNPAVED ROADS GEOLOGIC
RECONNAISSANCE PHOTOS
Mt. Murphy Road - Sections 5, 8 & 17
El Dorado County, California

FIGURE
19

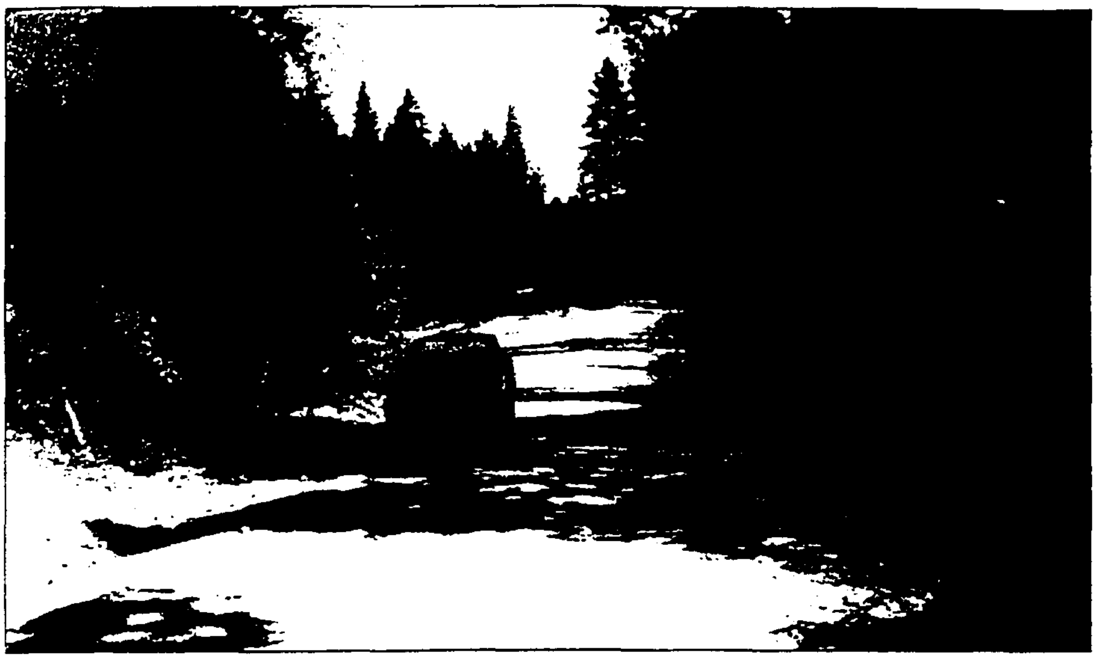

Photo 17: Park Creek Road - Western end of reconnaissance area.

Photo 18: Park Creek Road - Typical exposure of Mehrten Mudflow.

YOUNGDAHL & ASSOCIATES, INC. GEOTECHNICAL, ENVIRONMENTAL & CONSTRUCTION LAB	Project No.: 99292 **September 1999**	UNPAVED ROADS GEOLOGIC RECONNAISSANCE PHOTOS Park Creek Road - Section 3 El Dorado County, California	**FIGURE** **20**

Appendix E-3

Air Resources Board
Research Contract Road Study

CONTRACT NO. A032-147
FINAL REPORT
AUGUST 1992

Development of a Technique to Estimate Ambient Asbestos Downwind from Serpentine Covered Roadways

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

AIR RESOURCES BOARD
Research Division

E-3-1

DEVELOPMENT OF A TECHNIQUE TO ESTIMATE AMBIENT ASBESTOS DOWNWIND FROM SERPENTINE COVERED ROADWAYS

Final Report
Contract No. A032-147

Prepared for:

California Air Resources Board
Research Division
2020 L Street
Sacramento, CA 95814

Submitted by:

Valley Research Corporation
15904 Strathern Street, Suite 26
Van Nuys, CA 91406

Prepared by:

Yuji Horie
Steven Sidawi
Craig Tranby

AUGUST 1992

DISCLAIMER

ABSTRACT

In the foothills of the Sierra Nevada Mountains, serpentine rock has been mined extensively and widely used as a material for many types of unpaved surfaces, including parking lots, driveways, roads, and apparently even some school playgrounds. When vehicles are driven over unpaved roads surfaced with asbestos-containing serpentine material, asbestos fibers are released into the atmosphere as part of the resultant dust cloud. Thus persons near the roadway, especially on the downwind side, are exposed to elevated ambient concentration of asbestos. The goal of the present study was to quantify asbestos concentrations downwind of these roadways and relate the concentrations to vehicle traffic, road surface materials, and meteorological and climatological conditions.

After reviewing the occurrence of serpentine-covered unpaved roads in various parts of California and visiting roads throughout the State, it was found that the locale most suitable for study was in the vicinity of Oakdale in eastern Stanislaus County. After gaining permission from landowners, four sites were selected for field experiments. At each site, a network of four to five asbestos monitoring stations was established as well as a meteorological station for measuring wind speed and direction. During 5 to 8 one-hour test runs at each site, traffic was simulated on the road by repeated van trips while air samples were taken and meteorological conditions were monitored. Bulk samples of the road surface material were also taken for analysis of bulk asbestos content, silt content, and moisture content. Air samples were analyzed for asbestos using both optical and electron microscopes for two size ranges: all structures and structures ≥ 5 µm.

The EPA model that consists of the Copeland road dust emission model and Gaussian line source equation was evaluated by comparing measured asbestos concentrations with concentrations predicted by the model for the test conditions. The EPA model was found to be good only to estimate an order of magnitude of downwind concentrations. The structure of the model was found to be generally adequate, but the inclusion of both short temporal and long-term average parameters in the model appeared to decrease the accuracy of model estimates. Residual analysis of model-predicted concentrations less measured concentrations revealed that the model tends to overestimate asbestos concentrations at lower vehicle speeds and the model's performance is skewed with respect to model's site parameters such as moisture, silt, and asbestos contents.

A modified roadside asbestos model called CALSCRAM was developed by rectifying some of the defects found in the EPA model. The new model, which was calibrated over the range of 14% to 18% bulk asbestos content, was found to reduce the EPA model prediction errors by 76%. It is capable of predicting both short-term and long-term average asbestos concentrations and has a feature that accounts for the effect of a finite road segment on downwind concentrations.

ACKNOWLEDGMENTS

This roadway asbestos study could not have been completed without help from numerous individuals. Dr. Susanne Hering of Aerosol Dynamics, Inc., provided expert advice and assistance in designing the field experiments. Arthur Shrope of VRC and Dr. Wayne Harrington of ATC Environmental, Inc., contributed additional ideas and planning assistance early on in the project. For assistance during our site identification and selection effort we thank Tim Moore of the BLM in San Benito County, Scott Adams of the BLM in Lake County, the APCDs and Public Works Departments of northern and central California, the U.S. Forest Service staff in Stanislaus, El Dorado, and Shasta National Forests, and several cooperative private landowners. Arvid Severson of Severson Company, Inc., provided assistance with instrumentation. Larry Bregman and Dr. Charles Pyke of Continental Weather Service provided invaluable climatological assessments and weather forecasts for the field sites.

For their indefatigable assistance in asbestos sampling and analysis, the staff of ATC is gratefully acknowledged . Don Beck of ATC directed the field sampling effort with skill and dedication, and also contributed to many other facets of the project. Brian Urbaszewski of VRC and Dan Gawrys of ATC provided additional field assistance. Samples were analyzed by the staff of ATC's laboratory in Sioux Falls, SD.

The authors also thank the ARB staff for their valued input and guidance throughout the project: the Contract Manager Dr. Robert Grant of the Research Division; Victor Douglas, Ann Eli, and Todd Wong of the Stationary Source Division; and James McCormack of the Monitoring & Laboratory Division.

This report was submitted in fulfillment of ARB Contract No. A032-147 by Valley Research Corporation under the sponsorship of the California Air Resources Board. Work was completed as of August 1992.

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ABBREVIATIONS AND ACRONYMS

AACES-RS	Airborne Asbestos Concentration Estimator System-Roadway Screening, a computer code for the EPA model which was developed by Battelle Northwest Lab.
APCD	Air Pollution Control District
ARB	Air Resources Board
ATC	ATC Environmental Inc., subcontractor for asbestos sampling and analysis
ASTM	American Standards for Testing and Materials
CALSCRAM	California Serpentine-Covered Roadway Asbestos Model, the model developed under the present study
EDS	Energy Dispersive Spectroscopy
EPA	Environmental Protection Agency
ft	Feet
g	Gram
km/h	Kilometers per hour
m	Meter
mph	Miles per hour
m/s	Meters per second
NIOSH	National Institute for Occupational Safety and Health
NWS	National Weather Service
OSHA	Occupational Safety and Health Administration
PCM	Phase Contrast Microscopy
PLM	Polarized Light Microscopy
SAED	Selected Area Electron Diffraction
struc/cc	Structures per cubic centimeter
struc/g	Structures per gram
TEM	Transmission Electron Microscopy
TEM0	TEM-measured asbestos concentration for all structures having ≥ 3 to 1 aspect ratio regardless of size
TEM5	TEM-measured asbestos concentration for structures ≥5 µm and having ≥ 3 to 1 aspect ratio
µg	Microgram (10^{-6} gram)
vph	Vehicles per hour
VRC	Valley Research Corporation

1.0 INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

Serpentine rock is widespread in California. In the foothills of the Sierra Nevada mountains, serpentine rock has been mined extensively and has also been widely used as a material for many types of unpaved surfaces, including parking lots, driveways, roads, and apparently even some school playgrounds. It has an attractive blue-gray or greenish appearance, and it can be locally inexpensive and readily available. These factors, along with its superior compaction properties contribute to its frequent use in certain areas of the Sierra foothills.

Serpentine rock in many parts of California can also have a significant content of the chrysotile form of asbestos. Since 1986, when the California Air Resources Board (ARB) first identified asbestos as a toxic air contaminant, a number of bulk samples of serpentine material have been taken in California and analyzed for asbestos content. ARB has identified serpentine deposits with asbestos contents ranging from trace amounts to as high as 90 percent, with typical contents in the Sierra Nevada falling between 2 and 20 percent. Asbestos is a known human and animal carcinogen, and exposure to asbestos has been linked to a number of serious illnesses including lung cancer, mesothelioma, and asbestosis.

When vehicles are driven over unpaved roads surfaced with asbestos-containing serpentine material, asbestos fibers are released into the atmosphere as part of the resultant dust cloud. Thus persons near the roadway, especially on the downwind side, are exposed to elevated ambient concentration of asbestos. In response to these health concerns, many serpentine-covered roads in California have already been paved over, and regulations have been enacted to prevent further road surfacing with serpentine material having more than a 5% asbestos content. However, according to ARB (1990), there are still hundreds of miles of serpentine-covered roads in the State, and some of these roads are near residences or human activity.

1.1.1 BRIEF SUMMARY OF PREVIOUS RESEARCH

A number of studies conducted over the past 15 years along serpentine-covered roads have revealed high ambient levels of asbestos fibers generated by the mechanical action of vehicle traffic. The most ambitious of these was a 1987 study done by Ecology and Environment, Inc., for the U.S. Environmental Protection Agency (EPA), in which airborne asbestos concentrations downwind from a single roadway in Amador County were related to the asbestos content of the road surface material and simulated vehicle traffic on the roadway (EPA 1987, 1988). Several other investigations have looked at asbestos emissions from unpaved roads or off-road vehicle trails over native serpentine soil.

In the above EPA project, two different serpentine-covered roadways were originally selected for study, both on private property in the foothills east of Stockton and Sacramento. EPA personnel reached agreement with property owners at these two sites, and scheduled field work at both. However, work at one site was ultimately scrubbed due to unfavorable topography and wind conditions. Therefore, one road only, in western Amador County, was subjected to field experiments (EPA 1988).

To determine the effects of vehicle traffic on downwind concentrations of airborne asbestos, the EPA-sponsored study team erected meteorological monitoring and air sampling equipment downwind of the subject roadway (a single air sampling station was also placed upwind to determine background concentrations). The most distant downwind station was located at 100 ft. from the roadway. Experiments consisted of a series of one hour sampling runs, and some 8 hour sampling runs, during which a van was driven over a 100 ft. study section of the roadway at intervals of 15 minutes at a constant speed of 30 mph. No variations in these traffic conditions were attempted. Several bulk samples of the road surface material were also taken for analysis of asbestos content, silt content, and road moisture content. All bulk and air samples were forwarded to independent laboratories for phase contrast microscopy (PCM) or transmission electron microscopy (TEM) analysis. Laboratory results were entered into databases in conjunction with traffic and meteorological data specific to each sampling run.

As part of this EPA-sponsored work, a computer code was developed by Battelle Memorial Institute's Pacific Northwest Laboratory (Stenner et al. 1990). The code, named AACES-RS, uses a modified form of the Copeland Model (EPA 1985) to estimate downwind concentrations from a contaminated roadway. Among the improvements to the standard Copeland model found in the AACES-RS are the ability to analyze variable downwind distances instead of a fixed "within 50 feet" and consideration of wind speed and stability variables as model inputs. The primary input variables for the AACES-RS code are site specific silt content and asbestos content. For other input variables, AACES-RS contains default values but allows user input of the following variables:

1. Particle-Size Multiplier (k-factor)
2. Vehicle Speed
3. Vehicle Weight
4. Number of Wheels
5. Vehicle Frequency (number of vehicles per hour)
6. Vertical Dispersion Parameter (σ_z)
7. Distance from Road
8. Precipitation Days (number of days per year with precipitation)
9. Stability Class
10. Average Wind Speed
11. Initial Vertical Dispersion of Vehicle Wake (H)

The AACES-RS code (hereafter referred to as the "EPA model") was calibrated using the results of the EPA field work in Amador County. However, owing to the limited amount of field data and the narrow range of experimental conditions investigated, little improvement to the modified version of the Copeland Model was possible. Thus the model is believed to be accurate to an order of magnitude at best. Prior to the current study, the model has never been adequately validated or field tested.

1.1.2 OBJECTIVES

In California, there are at least hundreds of miles of existing roads that either traverse native serpentine soils or are surfaced with hauled-in serpentine material. Many of the health-related issues regarding these roads are still a subject of debate. However, a need has been recognized to evaluate existing roads and prioritize them as to their potential for contributing to public exposure to airborne asbestos. Since it would be prohibitively difficult to conduct individual field tests on all existing serpentine-covered roadways, a better approach would be to develop a predictive model which takes a few site specific parameters as model input and yields, as output, the ambient asbestos concentration as a function of distance from the roadway. Such a model can provide a cost effective way of evaluating a large number of roadways. The EPA has developed a model for such a purpose, but it has not been validated or field tested.

The primary objectives of this study, therefore, were to conduct field experiments at multiple sites in California under a wider range of conditions than had previously been investigated, and to use these results to validate and improve the existing EPA model or to replace it with an improved model.

1.2 SUMMARY AND CONCLUSIONS

After an extensive search for roadways suitable for study, several candidate serpentine-covered roadways were identified in the Sierra Nevada foothills. All were on private property. Permission to use them for study was sought and granted by most property owners. Field work was conducted during August and September, 1991, by Valley Research Corporation (VRC) and its subcontractor ATC Environmental, Inc.

Field work was completed at four sites, all of which were in the general vicinity of Oakdale in Stanislaus County. At each site, a 500 ft. section of the road was chosen for study. One air sampling station was set up upwind of the roadway and 3 to 4 stations were set up downwind. Two meteorological stations were also established, one to measure wind speed and direction; and the other to measure temperature and relative humidity. Several bulk samples of the road surface material were taken at each site, for analysis of silt content, asbestos content (by ARB Test Method 435), and moisture content. To make the study results usable for dispersion modeling, atmospheric stability variables were also recorded.

Field testing consisted of about six 1-hour experimental runs at each site. During the runs, traffic was simulated on the roadway by driving a van back and forth across the study section at designated speeds and time intervals. In total, four vehicle frequency conditions -- 5 vehicles per hour, 15 vehicles per hour, 45 vehicles per hour, and no traffic -- and two vehicle speeds -- 10 mph and 25 mph -- were investigated.

Air and road surface samples collected in the field were subjected to laboratory analyses. For bulk samples, these analyses were to determine asbestos content, silt content, and moisture content; for air samples, asbestos content by TEM and PCM analyses.

Results of the field experiments were compared to ambient asbestos concentrations predicted for the field conditions by the EPA model. Based on discrepancies between measured and model-predicted concentrations, a modified model, named CALSCRAM (California Serpentine-Covered Roadway Asbestos Model), was developed.

This study has yielded the following findings and conclusions:

- Although serpentine-covered unpaved roads indeed exist in many parts of California, nearly all unpaved roads covered with serpentine material on public land are either unsurfaced roads or off-road vehicle trails over native serpentine soil, or logging roads in mountainous, forested and often remote areas.
- Serpentine-covered unpaved roads in the vicinity of residences and centers of human activity suitable for field tests are common only in the Sierra Nevada foothills of California from approximately Mariposa County in the south to Placer County in the north.
- Traffic over serpentine-covered unpaved roads was found to generate measurably elevated levels of airborne asbestos at downwind distances to at least 250 feet.
- The EPA model for estimating airborne asbestos concentrations downwind of serpentine-covered roadways was found to predict concentrations accurately to an order of magnitude, but it performed poorly for low vehicle speeds and certain ranges of other input parameters.
- A modified model, called CALSCRAM, was developed based on the field data collected under the present study. This model not only out-performs the EPA model for estimating downwind asbestos concentrations but also possesses capabilities of predicting both short-term and long-term average concentrations. The model can also account for the effect of shorter road segments on downwind concentrations.

The model developed under this study provides a cost-effective tool for determining whether identified serpentine-covered unpaved roads pose risks of public exposure to elevated ambient levels of asbestos.

Although the model is capable of predicting asbestos concentrations downwind of unpaved roads surfaced with imported mined serpentine rock, it has not been tested on unsurfaced roads with native serpentine material. Therefore, recommendations for future research in the subject area are as follows:

(1) Design and implement a similar experiment to evaluate the model's applicability to unpaved roadways consisting of native serpentine material. These roadways appear to be far more prevalent in California than roadways surfaced with imported serpentine material.

(2) Develop a comprehensive compilation of unpaved roads in California covered by mined serpentine and native serpentine and determine their spatial distribution and vehicle activity levels.

(3) Identify regions in California where these roads occur in conjunction with human activity. Employ the model on roads in these regions to make first-order estimates of public exposure levels and develop priorities for further efforts on assessing health risks from such exposure.

2.0 EXPERIMENTAL METHODS

2.1 SELECTION OF STUDY SITES

Prior to this study, ARB staff estimated that in California there are at least 700 miles and possibly thousands of miles of publicly-owned serpentine-covered unpaved roads and possibly hundreds more miles that are privately-owned (ARB 1990). These estimates were based on conversations with several Air Pollution Control Districts (APCDs) in California counties with unpaved roads. However, no systematic compilation of either exact road mileage or road locations has yet been attempted. Thus there was no existing database to aid in the process of site selection for this study.

To aid in the identification of potential sites, we contacted knowledgeable officials at local APCDs, county public works departments, national forests and national parks, Bureau of Land Management, Caltrans, EPA, and ARB. Based on these conversations, we identified specific regions in California with potential study roads. A site reconnaissance tour of these regions was conducted for the purpose of identifying candidate sites and recording preliminary information on road characteristics, site topography, and meteorology, as well as for taking road surface samples for asbestos analysis.

Based on the results of the reconnaissance tour, it was concluded that although serpentine-covered unpaved roads indeed exist in many parts of California, the overwhelming majority do not meet basic experimental requirements, such as having a straight road segment, level terrain, and an absence of major obstructions such as trees or buildings. Moreover, nearly all unpaved roads covered with serpentine material on public land are either unsurfaced roads or offroad vehicle trails over native serpentine soil, or logging roads in mountainous, forested and often remote areas. These roads were not suited for the experimental approach.

Each candidate site was subjected to independent review first by meteorologists of Continental Weather Service and then by ARB staff. Based on this review, the pool of suitable candidate sites was reduced to several sites located in the vicinity of Oakdale in eastern Stanislaus County. The Oakdale region is distinct from other parts of the Sierra Nevada foothills in that most serpentine-covered roads are on open and level terrain. Outside of the Sierra Nevada, we were unable to locate <u>any</u> serpentine-covered roads other than unpaved roads over native serpentine material or roads with an unacceptably low serpentine content. One unpaved road over native serpentine material (in Lake County) was originally included in this study and subjected to preliminary field work, but results were ultimately excluded from the study by the ARB contract manager based on its native serpentine content and roadside slope.

The region north to northeast of Oakdale is characterized by flat and gently sloping open rangeland. Houses in this region are typically set far back in ranch-type parcels and connected to the paved public roads by straight driveways several hundred feet in length. A majority of these driveways are unpaved, and many of the unpaved driveways are surfaced with serpentine material. We identified an initial pool of about 10 straight, flat, serpentine road segments, which were primarily driveways. The property owners at each road segment were identified and contacted, and based on their receptiveness to our initial inquiries about use of their roads for the study, we reduced the number of candidate sites to 7. One liter bulk samples of the road surface material were taken and analyzed for asbestos content according to ARB Test Method 435, and each of the sites was found to have a chrysotile asbestos content within the range of 5 to 20 percent. Selection of final study sites was left until within a few days of each study period in order to incorporate the latest wind forecasts for selecting the road segments with optimal orientations.

The four study roads that were finally selected each had the distinctive "green" appearance of roadways covered with hauled-in serpentine, and each functioned as a driveway used for access between a public road and a private ranch. Three of the four had residences near or at the terminus of the roadway. All were on relatively flat and open rangeland, and three of the four had cattle or horses grazing in adjacent fields. Following is a more exact description of each study site:

Site 1: VRC Code: P5
Road Orientation: 165° (from magnetic north)
Roadside Terrain: Flat and open pasture, short grass.
Roadside Obstructions: Some small trees along the downwind roadside, barbed wire fences on either side.

Site 2: VRC Code: 7-3
Road Orientation: 167°
Roadside Terrain: Flat and open pasture, short grass.
Roadside Obstructions: Barbed wire fence on west side.

Site 3: VRC Code: P8
Road Orientation: 168°
Roadside Terrain: Flat and open pasture, somewhat marshy, vegetation about 2 to 3 ft. high.
Roadside Obstructions: None

Site 4: VRC Code: P9
Road Orientation: 73°
Roadside Terrain: Flat and open pasture, short grass.
Roadside Obstructions: Barbed wire-like fence to the south, chain-link fence to the north.

Figure 2-1 shows a map of the Oakdale region and the approximate locations of the four study sites.

2.2 EXECUTION OF FIELD EXPERIMENTS

The field experiments were conducted over 9 days during the months of August and September, 1991. Study personnel consisted of two VRC staff members and one ATC asbestos sampling technician. Each study day consisted of 2 to 4 one hour test runs during which samples of airborne asbestos were taken. The test runs were generally begun during a time when the wind was approximately perpendicular to the road segment under study. On most study days, such winds occurred during the afternoon hours.

2.2.1 PROTOCOL DEVELOPMENT AND STUDY DAY SELECTION

A detailed study protocol was developed specifying the methodologies to be employed in taking bulk samples, air samples, meteorological data, and in simulating traffic. A matrix specifying the traffic conditions designated for each experimental run was developed. Comprehensive equipment checklists were also prepared and thoroughly reviewed. Data sheets were prepared to be used by the field team to monitor the progress of the field tests.

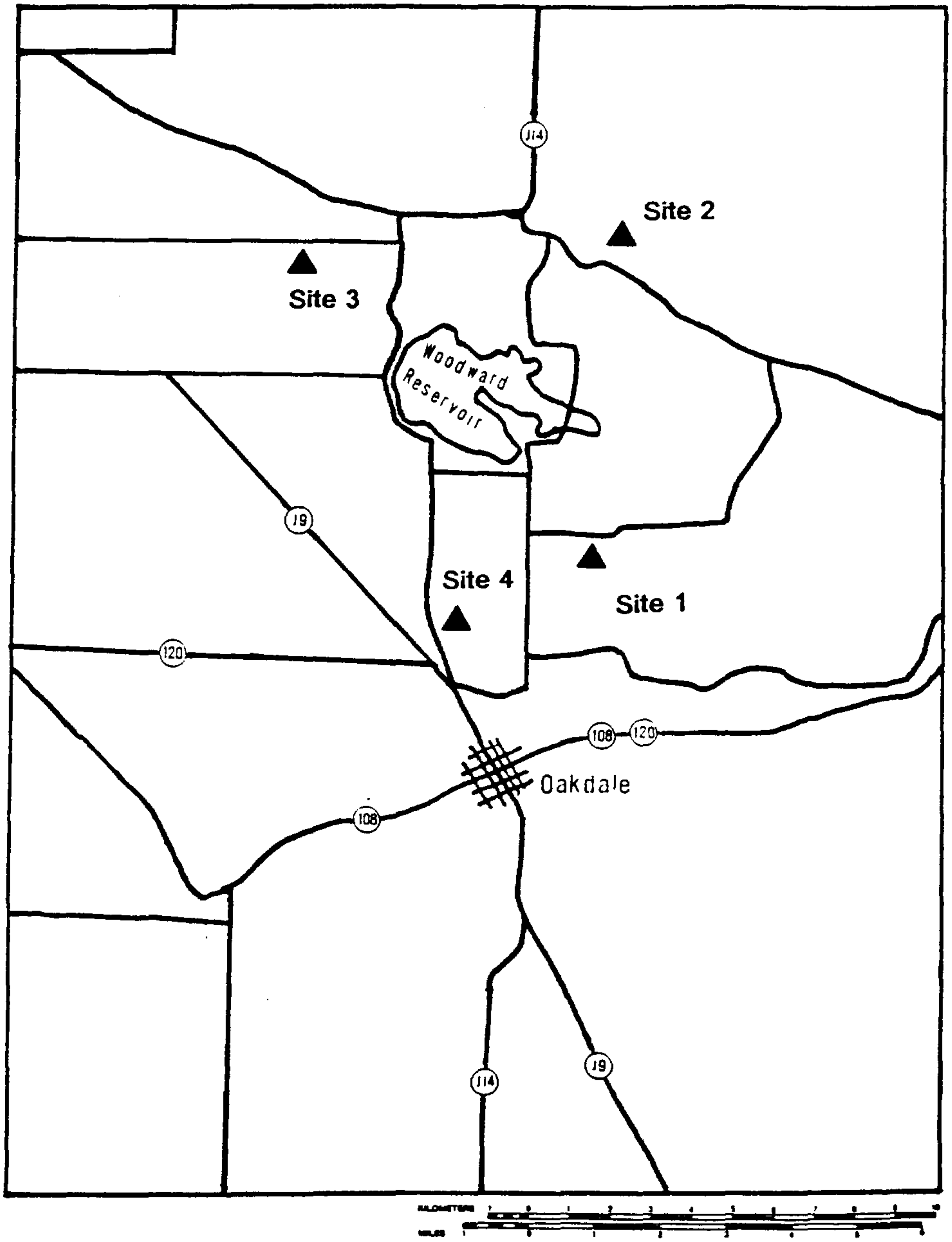

Figure 2-1. Map of the Oakdale Region Showing Locations of the Four Study Sites.

VRC made arrangements with meteorologists at Continental Weather Service to monitor weather conditions in the Oakdale region and provide detailed daily 4 day forecasts on wind speed and direction and rain probability beginning 3 to 4 days prior to any planned mobilization of the field team. Also, before visiting the first site studied, a VRC field assistant was dispatched to Oakdale 2 days in advance of the scheduled experiments to monitor winds with a handheld anemometer and verify the forecasts. Use of forecasts combined with advance site visits proved quite useful for selecting road segments with optimal orientations, and in one case for averting the mobilization of the entire field crew when rain was forecasted and confirmed prior to a scheduled field visit.

2.2.2 FIELD EXPERIMENT SETUP

Figure 2-2 depicts the arrangement of air sampling and meteorological monitoring stations in relation to the test road segment. The test segment has a 250 ft constant speed zone in each direction from the midpoint.

Each road segment's midpoint was chosen at a point relatively free of downwind obstruction with good roadside access, and where there was an adequate road length on either side. The study zone on the road segment, including the segment's midpoint and constant speed zone, was marked using a combination of traffic cones and stake wire flags.

The bearing of the test segment of the road was first measured with a compass, and all air samplers, at 4 to 5 air sampling stations, were then set up along a line perpendicular to the road segment's orientation. The first station was located at 50 ft. upwind from the road. The remaining stations were established downwind from the road at 25 ft., 75 ft., and 250 ft. A fifth station, termed the "distant sampler", was established at 1100 ft. at one site only. At the 25 ft. downwind station, samplers were mounted at heights of 1.5 m and 3 m, while at all other stations samplers were mounted at 1.5 m only. A floating replicate sampler was randomly placed at one of the stations prior to each test run.

At each site, a wind monitoring station was established 25 ft. upwind from the roadway so not to be affected by passing vehicles. A temperature and relative humidity station was established at the immediate roadside to measure conditions just above the road surface. The command station provided a central location for traffic and meteorological monitoring by the VRC field manager as well as for maintaining refreshments and miscellaneous research supplies.

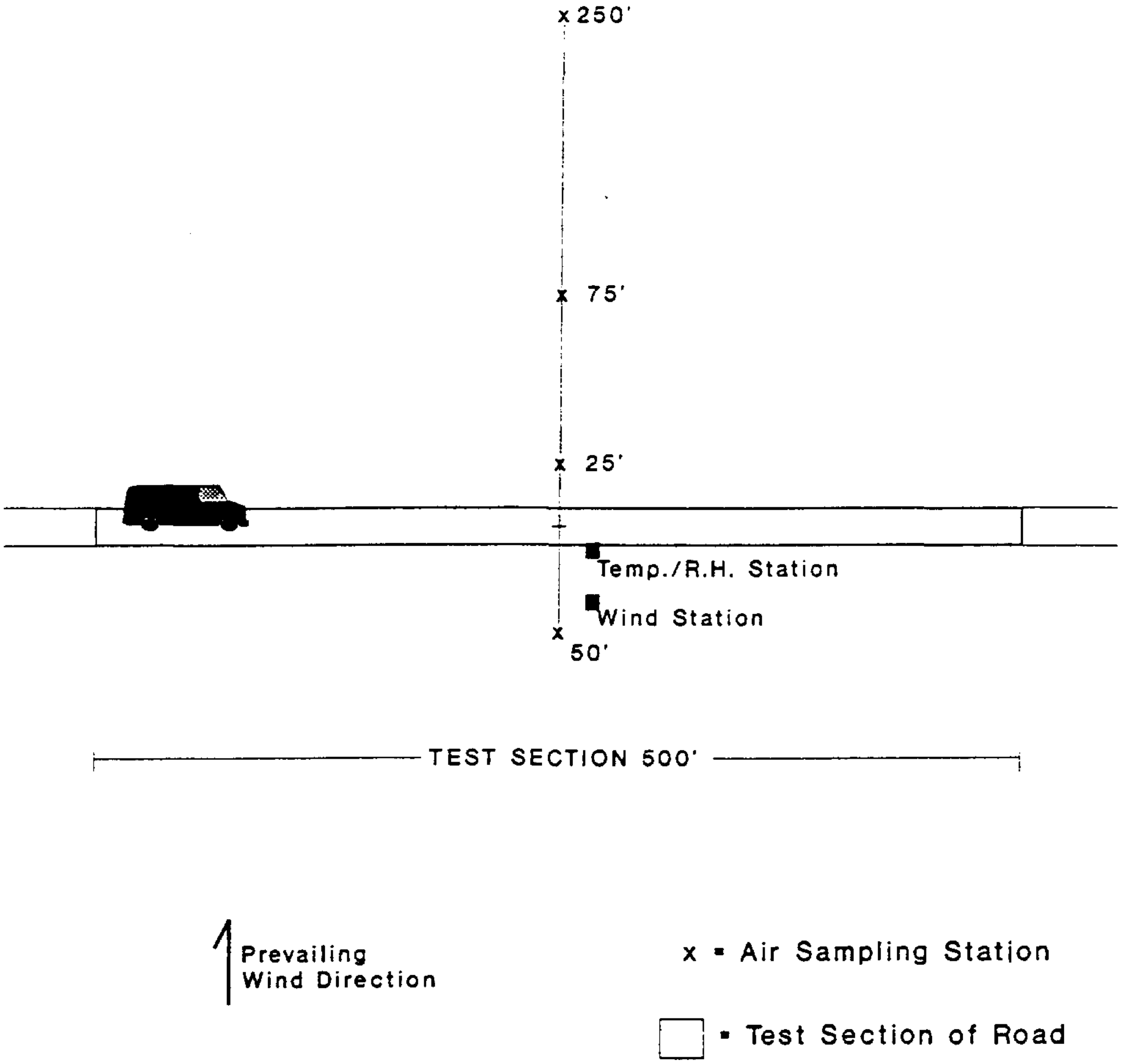

Figure 2-2. Setup Diagram for Study Sites.

2.2.3 TRAFFIC SIMULATION

For the purposes of eventual model development, the field tests were designed to focus on repeating similar traffic conditions rather than testing a multitude of traffic conditions without repeats. After considering issues such as expected dust generation per vehicle pass, real-world traffic conditions, and safety, traffic conditions were designated for 27 test runs as shown in Table 2-1. It was also decided that rather than trying to vary the vehicle type and weight, only one vehicle of "typical" size and weight would be used.

Table 2-1. DESIGNATED TRAFFIC CONDITIONS

Vehicle Speed (mph)	Vehicle Freq. (vph)	Number of Test Runs				
		Site 1	Site 2	Site 3	Site 4	Total
0	0	1	1	1	1	4
10	5	0	1	1	1	3
10	15	2	1	1	0	4
10	45	2	1	2	0	5
25	5	1	1	1	1	4
25	15	1	1	1	1	4
25	45	1	1	0	1	3

The vehicle speeds designated, 10 and 25 mph, are lower than the assumed average vehicle speed of 30 mph in the EPA study. The AACES-RS code uses a default value of 30 mph based on a survey of drivers on unpaved roads in the St. Louis area by Cowherd and Guenther (1976). Serpentine covered roads in California, however, are typically found as winding roads in the foothills or as rural driveways, where vehicle speeds are likely to be slower, for reasons of safety (in the case of winding roads) and to minimize dust generation (especially when near residences). Although typical vehicle frequencies on these serpentine-covered roads are likely to be less than 1 or 2 vehicles per hour, higher frequencies of 5, 15 and 45 vehicles per hour were employed for this study in order to ensure that the traffic would generate a measurable range of airborne asbestos concentrations.

At each study site, the first test run was conducted to determine the "background" asbestos level, namely, concentrations present prior to the experiment. This involved completion of a one hour sampling period with no traffic on the road segment. On subsequent runs, traffic was "simulated" by a single unloaded cargo van (Ford Econoline 150, unladen weight 1.8 tons) driven by a VRC staff member. The van was driven over the study segment at constant speed and at regular intervals both specified in advance. The driver and field manager maintained constant audio contact via two-way radios. Each time the study vehicle passed the midpoint of the road segment, the field manager noted on the traffic data sheet the exact time, vehicle direction, and vehicle type.

Occasionally, during the course of the experiments, access to the road was requested by non-study vehicles which were stopped and informed of the study and asked either to drive through at 2 mph (to minimize disturbance) or to pass at the designated time and speed as a substitute for the study van. The vehicle type (e.g., auto, pickup, van), speed, direction, and the time were noted for all non-study vehicles.

2.2.4 METEOROLOGICAL MONITORING

Wind speed and direction were measured continuously during each entire study day with a Young wind sensor Model 05103 (combination vane and anemometer) mounted on a 10' tripod. The following data items were automatically recorded in a Campbell Scientific, Inc., datalogger once each minute: time, mean absolute wind speed, vector wind speed, mean wind direction, and standard deviation of the wind direction. At the end of each study day, all data were downloaded to a laptop computer for quality checks and backup to hard and floppy disks.

Temperature and relative humidity readings were recorded manually each 30 minutes from an Oakton hygrometer/thermometer placed in a well-ventilated shaded area approximately 6 feet above ground level at the edge of the study road. Percent cloud cover was also recorded for each experimental run and solar angle was calculated based on the time of the run. These cloud cover and solar angle data in conjunction with wind data were later used to determine the atmospheric stability class for each test run.

2.2.5 BULK SAMPLING

In addition to the previously noted screening samples, at each site three "composite" bulk samples of the road surface material were taken and analyzed for asbestos content according to ARB Test Method 435. Composite samples were also taken prior to each test run and analyzed for moisture and silt content.

All bulk samples were taken using a clean round-tipped shovel. Each sample was taken from approximately the top 1/2 inch of the road surface at three longitudinal distances on the road segment: at the midpoint and at points 150' from the midpoint in either direction along the roadway. Samples were sealed in sterile 1 liter containers.

2.2.6 AIR SAMPLING

As mentioned earlier, four air sampling stations were established along a line perpendicular to the roadway -- one upwind (50 ft.) and 3 downwind (25 ft., 75 ft., and 250 ft.). A fifth station, the distant sampler, was established at one site only. All but the 25 ft. downwind station consisted of a single air collection pump with a filter sampler mounted at 1.5 m. The 25 ft. station consisted of two air collection pumps with one sampler mounted at 1.5 m from the ground and another at 3 m. Additionally, one "floating" sampler was collocated to acquire a replicate sample for each of the test runs . Because no other power source was available, portable generators were used to power all air pumps.

Before each one hour test run, each sampler was loaded with a labeled mixed-cellulose ester filter cassette with a .45 micron pore size. At the signal of the field manager, the pumps were turned on at the start of the run. Flow rates for each of the samplers were measured, using "The Gilibrator" primary flow electronic calibrator (Gilian Instrument Corp.) near the beginning and end of the run. At the end of the run, power to the air pumps was turned off and the filter cassettes were collected and sealed. The distant sampler, used 2 days at a single study site, was turned on at the beginning of the study day and turned off at the end. For the "background" test runs, which occurred once per site, only 3 samplers were used: upwind 50 ft., downwind 25 ft. at 1.5 m, and downwind 75 ft.

As a routine quality assurance measure, "field blanks" and "lab blanks" were collected once per site. The purpose was to establish the integrity of the sampling cassettes in the handling process both at the site and in the laboratory.

2.3 LABORATORY METHODS

All field samples were clearly labeled, packaged, and transported according to ATC's chain-of-custody procedures. The following paragraphs briefly describe the laboratory procedures that were used for silt/moisture content analysis, bulk sample analysis, and PCM and TEM analyses of air samples.

2.3.1 SILT AND MOISTURE CONTENT ANALYSIS

Moisture content for the bulk samples was determined according to ASTM Method D2216 which is a standard test method for laboratory determination of water (moisture) content of soil and rock. The method consists of oven drying the samples at 110°C to a constant mass. Moisture content is then calculated from the difference in sample weight before and after drying.

Silt content determination was based on ASTM Method D1140 which is a standard test method for quantifying the amount of material in soils finer than a No. 200 sieve. The method consists of washing and dry-sieving samples through nested sieves (upper sieve is a No. 40 and lower sieve is a No. 200). Silt content, or percentage of material finer than a No. 200 sieve, is based on the dry weight of the sample after washing and dry-sieving divided by the original sample dry weight.

2.3.2 BULK SAMPLE ASBESTOS ANALYSIS

Bulk sample preparation was accomplished by crushing the material to a nominal size of less than 0.375 inch. The sample volume was reduced to one pint as per ASTM Method C-702-80. The one pint sample was further reduced in particle size to produce a material of which the majority passed a 200 mesh Tyler screen.

The one pint sample was first examined macroscopically for color, texture, homogeneity, and visible fibers. A portion of the sample was placed on a watchglass and its fibrous content was examined under a stereomicroscope. An aliquot of the sample was removed and spread out on a glass slide. Two drops of 1.55 refractive index solution was added to the aliquot and a coverslip was placed on top of the slide. Three slides were prepared for each sample.

The slides were then examined under polarized light microscopy where fibrous structures were analyzed noting color and pleochroism, morphology, index of refraction, extinction, sign of elongation, and dispersion staining colors. Once the fibrous content was identified, a visual percentage estimate was recorded based on macroscopic and microscopic observations.

Asbestos content was then quantified according to ARB Test Method 435.

2.3.3 AIR SAMPLE ASBESTOS ANALYSIS

All air samples were subjected to TEM and PCM analyses in ATC's laboratory in Sioux Falls, SD. TEM analysis followed the microscopic methods according to EPA's AHERA Method. A set number of 200-mesh electron microscopy grid openings were analyzed as governed by the grid opening and the analytical sensitivity. Structure counting criteria were based on being greater than 0.25 microns in length with a length-to-width ratio of 3:1 or greater. Structures meeting the counting criteria were analyzed by selected area electron diffraction (SAED) and Energy-Dispersive Spectroscopy (EDS) for asbestos identification. It should be pointed out that although most of the fibers can be identified as asbestos or non-asbestos, there are still some cases where a fiber will have borderline data and thus cannot be ruled out as non-asbestos. These "borderline" fibers were labeled ambiguous, but were included in the asbestos calculations.

A portion of each sample was analyzed by PCM according to NIOSH Method 7400. The samples were prepared by removing a pie-shaped wedged portion from each sample cassette filter. The samples were then mounted by the acetone/triacetin on individual sample slides. The microscope was set up and its optics were adjusted according to the 7400 Method. The slide was examined under the microscope where the 7400 Method counting rules were implemented. Only fibers equal to or greater than 5 micrometers in length with an aspect ratio of 3:1 or greater were counted. Slides were examined until a fiber count of 100 or a field count of 100 is yielded with a minimum of at least 20 fields examined. The fiber concentration was then calculated based on the microscope graticule field area, filter cassette field area, sample volume, fiber count, and field count. All air sampling results were examined for consistency and anomalies before and after being entered into VRC's computer system.

3.0 RESULTS OF FIELD EXPERIMENTS

3.1 ACTUAL TRAFFIC CONDITIONS AND AIR SAMPLING CONFIGURATIONS

Both the traffic conditions (i.e., vehicle speed and frequency) and the configuration for active air samplers for each test run were designated prior to execution of the field experiments. In general, the field team was able to conform to these designations. On 3 occasions, however, a predesignated test run was completed but later discarded after review of the wind conditions. Table 3-1 summarizes the number of bulk and air samples analyzed for each traffic condition. Table 3-2 shows in detail for each test run the actual traffic conditions and active air sampler configuration. A symbol indicates that TEM and PCM analyses were performed for a particular sample. Test runs containing no symbols are those that were discarded due to poor wind conditions.

3.2 AIR AND BULK ASBESTOS SAMPLES

Table 3-3 summarizes the TEM-measured asbestos concentrations (i.e., TEM0 for total structures having ≥ 3-to-1 aspect ratios regardless of size) at each study site, according to the traffic conditions for the test runs. The table shows measured ambient asbestos concentrations both upwind and downwind of each roadway. For all test runs with simulated traffic, concentrations were higher downwind (note: upwind samples are all at 50 ft). Concentrations were generally higher on test runs with higher vehicle speed and frequency. Table 3-4 presents a more detailed summary of the TEM, PCM, and bulk sample analyses results for each test run at each site. The table corresponds to the actual traffic conditions and air sampling configuration shown in Table 3-2. Note that the bulk asbestos content of the road surface material is the mean of three composite samples. Also, note that the last sample listed under each test run is a collocated sample, included to test the variability observed between two samplers at similar locations.

Of the 128 air samples analyzed by TEM, about 93% were positive for chrysotile asbestos. Amphibole and "Ambiguous" were the other designated forms of asbestos and occurred in trace amounts in 15.6% and 4.7% of the samples respectively. Non-asbestos fibers identified were grouped into Antigorite and "Other" and occurred in trace amounts in 9.4% and 18.8%

Table 3-1. SUMMARY OF TEST CONDITIONS AND BULK AND AIR SAMPLES ANALYZED

Vehicle Speed (mph)	Vehicle Freq. (vph)	Bulk Samples		Air Samples Analyzed				
		Asbestos	Moisture & Silt[a]	Blank[b]	Back-ground[c]	Upwind	Down-wind	All Day Sample[d]
0	0	4	4	0	12	4	8	1
10	5	0	2	0	0	2	10	0
10	15	0	4	0	0	3	15	1
10	45	3	5	4	0	4	20	0
25	5	0	3	0	0	3	15	0
25	15	3	4	0	0	4	20	0
25	45	2	3	4	0	3	15	0
Total		12	25	8	12	19	95	2

[a] Some moisture and silt analyses were performed on the same sample as used for bulk asbestos content analysis.

[b] Both field and laboratory blanks.

[c] For background asbestos concentrations present prior to road tests.

[d] Two all day samples were analyzed. They were each collected on days with 3 to 4 test runs.

Table 3-2. ACTUAL TRAFFIC CONDITIONS AND AIR SAMPLING CONFIGURATION FOR EACH TEST RUN

Site No.	Test Run	Veh. Speed (mph)	Veh. Freq. (vph)	Type and Location of Air Samples Analyzed									Total No. of Samples
				1	2	3	4	5	6	7	8	9	
1	1	0	0			■	■		■				3
1	2	10	45	■	■								2
1	3	25	15			■	■	■	■	■		■	6
1	4	10	15										0*
1	5	25	5			■	■	■	■	■		■	6
1	6	25	45			■	■	■	■	■		■	6
1	7	10	15			■	■	■	■	■		■	6
1	8	10	45			■	■	■	■	■		■	6
2	1	0	0			■	■		■		◆		4
2	2	25	45	■	■	■	■	■	■	■		■	8
2	3	10	45			■	■	■	■	■		■	6
2	4	25	15			■	■	■	■	■		■	6
2	5	10	15			■	■	■	■	■	◆	■	7
2	6	25	5			■	■	■	■	■		■	6
2	7	10	5			■	■	■	■	■		■	6
3	1	0	0			■	■		■				3
3	2	10	45	■	■	■	■	■	■	■		■	8
3	3	25	15			■	■	■	■	■		■	6
3	4	10	15			■	■	■	■	■		■	6
3	5	25	5			■	■	■	■	■		■	6
3	6	10	5			■	■	■	■	■		■	6
3	7	10	45			■	■	■	■	■		■	6
4	1	0	0			■	■		■				3
4	2	25	45	■	■	■	■	■	■	■		■	8
4	3	25	15			■	■	■	■	■		■	6
4	4	25	5										0*
4	5	10	5										0*

Samplers:

1. Field Blank
2. Lab Blank
3. Upwind 50'/1.5m
4. Downwind 25'/1.5m
5. Downwind 25'/3m
6. Downwind 75'/1.5m
7. Downwind 250'/1.5m
8. Downwind 1100'/1.5m
9. Replicate (floating)

■ One hour sample
◆ Continuous sample (all day)
*Due to poor wind conditions

Table 3-3. SUMMARY OF TEST CONDITIONS AND TEM-MEASURED ASBESTOS CONCENTRATIONS AT EACH STUDY SITE

Study Site	Test Run	Veh. Speed (mph)	Veh. Freq. (vph)	TEM0 (struc./cc)	
				Upwind	Downwind
1	1	0	0	.02	.01 - .08
1	4, 7	10	15	.01	.15 - .44
1	2, 8	10	45	.14	.59 - 1.87
1	5	25	5	.01	.25 - 7.25
1	3	25	15	.02	.94 - 3.23
1	6	25	45	.02	3.83 - 10.04
2	1	0	0	.01	.01
2	7	10	5	.01	.00* - .21
2	5	10	15	.01	.00* - 1.34
2	3	10	45	.01	.03* - 2.07
2	6	25	5	.02	.00* - 3.99
2	4	25	15	.05	.04* - 4.10
2	2	25	45	.01	.00 - 9.57
3	1	0	0	.02	.04 - .11
3	6	10	5	.01	.04 - .17
3	4	10	15	.02	.10 - .56
3	2, 7	10	45	.01 - .02	.05 - 4.01
3	5	25	5	.01	.47 - 1.66
3	3	25	15	.04	.55 - 7.59
4	1	0	0	.02	.02 - .05
4	3	25	15	.01	1.05 - 5.28
4	2	25	45	.01	2.65 - 14.20

* At 1100 ft downwind

Table 3-4. SUMMARY OF AIR AND BULK SAMPLE ANALYSIS RESULTS

	DATE	RUN	TIME START	VEH. SPEED (MPH)	VEH. FREQ. (VPH)	STAB. CLASS	SAMPLER DIST. (FT)	SAMPLER HEIGHT (M)	BULK ASB. CONT.[a]	MOIS-TURE CONT.[b]	SILT CONT.[b]	PCM CONC.[c] (F/CC)	TEM-MEASURED CONC. >=5u (STRUC/CC)	ALL (STRUC/CC)
SITE 1														
	8/19/91	1	13:55	0	0	B	50	1.5	14.0	.3	4.8	.01	0.00	.02
	8/19/91	1	13:55	0	0	B	25	1.5	14.0	.3	4.8	.01	.02	.08
	8/19/91	1	13:55	0	0	B	75	1.5	14.0	.3	4.8	.01	.01	.01
	8/19/91	3	17:40	25	15	B	50	1.5	14.0	.1	8.0	.01	0.00	.02
	8/19/91	3	17:40	25	15	B	25	1.5	14.0	.1	8.0	.02	.24	3.23
	8/19/91	3	17:40	25	15	B	25	3.0	14.0	.1	8.0	.02	.06	1.38
	8/19/91	3	17:40	25	15	B	75	1.5	14.0	.1	8.0	.02	.02	.94
	8/19/91	3	17:40	25	15	B	250	1.5	14.0	.1	8.0	.01	.04	1.42
	8/19/91	3	17:40	25	15	B	75	1.5	14.0	.1	8.0	.01	.10	2.56
	8/20/91	5	14:28	25	5	C	50	1.5	14.0	.4	9.3	.01	0.00	.01
	8/20/91	5	14:28	25	5	C	25	1.5	14.0	.4	9.3	.05	.32	7.25
	8/20/91	5	14:28	25	5	C	25	3.0	14.0	.4	9.3	.01	.07	1.67
	8/20/91	5	14:28	25	5	C	75	1.5	14.0	.4	9.3	.02	.14	3.59
	8/20/91	5	14:28	25	5	C	250	1.5	14.0	.4	9.3	.01	.01	.25
	8/20/91	5	14:28	25	5	C	25	1.5	14.0	.4	9.3	.06	.27	5.47
	8/20/91	6	17:08	25	45	C	50	1.5	14.0	.6	6.9	.01	0.00	.02
	8/20/91	6	17:08	25	45	C	25	1.5	14.0	.6	6.9	.15	.94	9.12
	8/20/91	6	17:08	25	45	C	25	3.0	14.0	.6	6.9	.10	.47	4.67
	8/20/91	6	17:08	25	45	C	75	1.5	14.0	.6	6.9	.08	.48	5.41
	8/20/91	6	17:08	25	45	C	250	1.5	14.0	.6	6.9	.05	.34	3.83
	8/20/91	6	17:08	25	45	C	75	1.5	14.0	.6	6.9	.07	.65	10.04
	8/23/91	7	12:35	10	15	B	50	1.5	14.0	.8	9.9	.01	0.00	.01
	8/23/91	7	12:35	10	15	B	25	1.5	14.0	.8	9.9	.01	.02	.44
	8/23/91	7	12:35	10	15	B	25	3.0	14.0	.8	9.9	.01	.32	.37
	8/23/91	7	12:35	10	15	B	75	1.5	14.0	.8	9.9	.01	.03	.26
	8/23/91	7	12:35	10	15	B	250	1.5	14.0	.8	9.9	.01	0.00	.15
	8/23/91	7	12:35	10	15	B	25	1.5	14.0	.8	9.9	.01	0.00	.06
	8/23/91	8	14:00	10	45	B	50	1.5	14.0	.7	9.9	.01	.01	.14
	8/23/91	8	14:00	10	45	B	25	1.5	14.0	.7	9.9	.02	.18	1.87
	8/23/91	8	14:00	10	45	B	25	3.0	14.0	.7	9.9	.02	.05	1.27
	8/23/91	8	14:00	10	45	B	75	1.5	14.0	.7	9.9	.01	.07	.77
	8/23/91	8	14:00	10	45	B	250	1.5	14.0	.7	9.9	.01	.03	.59
	8/23/91	8	14:00	10	45	B	25	1.5	14.0	.7	9.9	.01	.17	1.76
SITE 2														
	8/21/91	1	13:35	0	0	B	50	1.5	14.0	.3	4.9	.01	0.00	.01
	8/21/91	1	13:35	0	0	B	25	1.5	14.0	.3	4.9	.01	0.00	.01
	8/21/91	1	13:35	0	0	B	75	1.5	14.0	.3	4.9	.01	0.00	.01
	8/21/91	2	14:40	25	45	B	50	1.5	14.0	.5	4.8	.01	0.00	.01
	8/21/91	2	14:40	25	45	B	25	1.5	14.0	.5	4.8	.09	1.57	9.57
	8/21/91	2	14:40	25	45	B	25	3.0	14.0	.5	4.8	.07	.41	5.00
	8/21/91	2	14:40	25	45	B	75	1.5	14.0	.5	4.8	.06	.32	5.78
	8/21/91	2	14:40	25	45	B	250	1.5	14.0	.5	4.8	.02	.05	1.66
	8/21/91	2	14:40	25	45	B	1100	1.5	14.0	.5	4.8	.00	.01	.04
	8/21/91	2	14:40	25	45	B	25	1.5	14.0	.5	4.8	.10	.81	6.15
	8/21/91	3	15:52	10	45	C	50	1.5	14.0	.2	4.5	.01	0.00	.01
	8/21/91	3	15:52	10	45	C	25	1.5	14.0	.2	4.5	.02	.17	1.74
	8/21/91	3	15:52	10	45	C	25	3.0	14.0	.2	4.5	.01	.18	2.11
	8/21/91	3	15:52	10	45	C	75	1.5	14.0	.2	4.5	.02	.15	2.07
	8/21/91	3	15:52	10	45	C	250	1.5	14.0	.2	4.5	.01	.04	.46
	8/21/91	3	15:52	10	45	C	1100	1.5	14.0	.2	4.5	.00	.01	.04

Table 3-4 (continued) - 2

DATE	RUN	TIME START	VEH. SPEED (MPH)	VEH. FREQ. (VPH)	STAB. CLASS	SAMPLER DIST. (FT)	SAMPLER HEIGHT (M)	BULK ASB. CONT.[a]	MOISTURE CONT.[b]	SILT CONT.[b]	PCM CONC.[c] (F/CC)	TEM-MEASURED CONC. >=5u (STRUC/CC)	ALL (STRUC/CC)
8/21/91	3	15:52	10	45	C	75	1.5	14.0	.2	4.5	.01	.22	2.04
8/21/91	4	17:10	25	15	C	50	1.5	14.0	.2	5.9	.01	0.00	.05
8/21/91	4	17:10	25	15	C	25	1.5	14.0	.2	5.9	.03	.42	4.35
8/21/91	4	17:10	25	15	C	25	3.0	14.0	.2	5.9	.02	.29	4.10
8/21/91	4	17:10	25	15	C	75	1.5	14.0	.2	5.9	.04	.22	2.41
8/21/91	4	17:10	25	15	C	250	1.5	14.0	.2	5.9	.01	.06	1.31
8/21/91	4	17:10	25	15	C	1100	1.5	14.0	.2	5.9	.00	.01	.04
8/21/91	4	17:10	25	15	C	250	1.5	14.0	.2	5.9	.01	.19	1.17
8/22/91	5	13:05	10	15	B	50	1.5	14.0	.3	5.5	.01	0.00	.01
8/22/91	5	13:05	10	15	B	25	1.5	14.0	.3	5.5	.01	.03	.77
8/22/91	5	13:05	10	15	B	25	3.0	14.0	.3	5.5	.01	.02	1.34
8/22/91	5	13:05	10	15	B	75	1.5	14.0	.3	5.5	.01	.04	.56
8/22/91	5	13:05	10	15	B	250	1.5	14.0	.3	5.5	.01	.01	.09
8/22/91	5	13:05	10	15	B	1100	1.5	14.0	.3	5.5	.01	.01	.01
8/22/91	5	13:05	10	15	B	50	1.5	14.0	.3	5.5	.01	0.00	.01
8/22/91	6	14:35	25	5	B	50	1.5	14.0	.3	6.1	.01	0.00	.02
8/22/91	6	14:35	25	5	B	25	1.5	14.0	.3	6.1	.03	.25	3.90
8/22/91	6	14:35	25	5	B	25	3.0	14.0	.3	6.1	.01	.21	2.52
8/22/91	6	14:35	25	5	B	75	1.5	14.0	.3	6.1	.01	.08	1.32
8/22/91	6	14:35	25	5	B	250	1.5	14.0	.3	6.1	.01	.05	.46
8/22/91	6	14:35	25	5	B	1100	1.5	14.0	.3	6.1	.01	.01	.01
8/22/91	6	14:35	25	5	B	25	1.5	14.0	.3	6.1	.02	.38	3.99
8/22/91	7	15:55	10	5	B	50	1.5	14.0	.3	5.6	.01	0.00	.01
8/22/91	7	15:55	10	5	B	25	1.5	14.0	.3	5.6	.01	.03	.21
8/22/91	7	15:55	10	5	B	25	3.0	14.0	.3	5.6	.01	.01	.11
8/22/91	7	15:55	10	5	B	75	1.5	14.0	.3	5.6	.01	0.00	.08
8/22/91	7	15:55	10	5	B	250	1.5	14.0	.3	5.6	.01	0.00	.01
8/22/91	7	15:55	10	5	B	1100	1.5	14.0	.3	5.6	.01	.01	.01
8/22/91	7	15:55	10	5	B	75	1.5	14.0	.3	5.6	.01	0.00	.06
SITE 3													
9/12/91	1	11:50	0	0	B	50	1.5	18.3	.8	6.9	.01	0.00	.02
9/12/91	1	11:50	0	0	B	25	1.5	18.3	.8	6.9	.01	.01	.11
9/12/91	1	11:50	0	0	B	75	1.5	18.3	.8	6.9	.01	0.00	.04
9/12/91	2	14:50	10	45	B	50	1.5	18.3	1.9	5.6	.01	0.00	.03
9/12/91	2	14:50	10	45	B	25	1.5	18.3	1.9	5.6	.01	.08	1.22
9/12/91	2	14:50	10	45	B	25	3.0	18.3	1.9	5.6	.01	.02	.88
9/12/91	2	14:50	10	45	B	75	1.5	18.3	1.9	5.6	.01	.06	.84
9/12/91	2	14:50	10	45	B	250	1.5	18.3	1.9	5.6	.01	.01	.21
9/12/91	2	14:50	10	45	B	50	1.5	18.3	1.9	5.6	.01	0.00	.05
9/12/91	3	15:52	25	15	B	50	1.5	18.3	1.5	10.3	.01	0.00	.05
9/12/91	3	15:52	25	15	B	25	1.5	18.3	1.5	10.3	.05	.09	8.32
9/12/91	3	15:52	25	15	B	25	3.0	18.3	1.5	10.3	.02	.28	3.43
9/12/91	3	15:52	25	15	B	75	1.5	18.3	1.5	10.3	.05	.29	2.42
9/12/91	3	15:52	25	15	B	250	1.5	18.3	1.5	10.3	.01	.03	.55
9/12/91	3	15:52	25	15	B	25	1.5	18.3	1.5	10.3	.05	.35	5.33
9/13/91	4	12:12	10	15	A	50	1.5	18.3	1.2	6.4	.01	0.00	.02
9/13/91	4	12:12	10	15	A	25	1.5	18.3	1.2	6.4	.01	.02	.56
9/13/91	4	12:12	10	15	A	25	3.0	18.3	1.2	6.4	.01	0.00	.39
9/13/91	4	12:12	10	15	A	75	1.5	18.3	1.2	6.4	.01	.02	.11
9/13/91	4	12:12	10	15	A	250	1.5	18.3	1.2	6.4	.01	0.00	.10
9/13/91	4	12:12	10	15	A	75	1.5	18.3	1.2	6.4	.01	.01	.14

Table 3-4 (continued) - 3

DATE	RUN	TIME START	VEH. SPEED (MPH)	VEH. FREQ. (VPH)	STAB. CLASS	SAMPLER DIST. (FT)	SAMPLER HEIGHT (M)	BULK ASB. CONT.[a]	MOIS-TURE CONT.[b]	SILT CONT.[b]	PCM CONC.[c] (F/CC)	TEM-MEASURED CONC. >=5u (STRUC/CC)	ALL (STRUC/CC)
9/13/91	5	13:21	25	5	B	50	1.5	18.3	1.4	7.4	.01	0.00	.01
9/13/91	5	13:21	25	5	B	25	1.5	18.3	1.4	7.4	.02	.12	1.66
9/13/91	5	13:21	25	5	B	25	3.0	18.3	1.4	7.4	.02	.09	1.05
9/13/91	5	13:21	25	5	B	75	1.5	18.3	1.4	7.4	.01	.03	.74
9/13/91	5	13:21	25	5	B	250	1.5	18.3	1.4	7.4	.01	.03	.47
9/13/91	5	13:21	25	5	B	250	1.5	18.3	1.4	7.4	.01	.04	.51
9/13/91	6	14:28	10	5	B	50	1.5	18.3	1.2	6.4	.01	0.00	.01
9/13/91	6	14:28	10	5	B	25	1.5	18.3	1.2	6.4	.01	.01	.17
9/13/91	6	14:28	10	5	B	25	3.0	18.3	1.2	6.4	.01	0.00	.05
9/13/91	6	14:28	10	5	B	75	1.5	18.3	1.2	6.4	.01	.02	.15
9/13/91	6	14:28	10	5	B	250	1.5	18.3	1.2	6.4	.01	0.00	.04
9/13/91	6	14:28	10	5	B	25	3.0	18.3	1.2	6.4	.01	0.00	.04
9/13/91	7	15:40	10	45	C	50	1.5	18.3	.4	7.4	.01	0.00	.01
9/13/91	7	15:40	10	45	C	25	1.5	18.3	.4	7.4	.03	.24	4.01
9/13/91	7	15:40	10	45	C	25	3.0	18.3	.4	7.4	.01	.03	.77
9/13/91	7	15:40	10	45	C	75	1.5	18.3	.4	7.4	.01	.12	1.16
9/13/91	7	15:40	10	45	C	250	1.5	18.3	.4	7.4	.01	.01	.39
SITE 4													
9/14/91	1	11:48	0	0	B	50	1.5	16.7	.7	7.8	.01	0.00	.02
9/14/91	1	11:48	0	0	B	25	1.5	16.7	.7	7.8	.01	0.00	.02
9/14/91	1	11:48	0	0	B	75	1.5	16.7	.7	7.8	.01	0.00	.05
9/14/91	2	13:47	25	45	B	50	1.5	16.7	.7	7.1	.01	0.00	.01
9/14/91	2	13:47	25	45	B	25	1.5	16.7	.7	7.1	.14	1.10	14.20
9/14/91	2	13:47	25	45	B	25	3.0	16.7	.7	7.1	.09	.52	6.64
9/14/91	2	13:47	25	45	B	75	1.5	16.7	.7	7.1	.12	.24	6.72
9/14/91	2	13:47	25	45	B	250	1.5	16.7	.7	7.1	.02	.22	3.86
9/14/91	2	13:47	25	45	B	250	1.5	16.7	.7	7.1	.03	.12	2.66
9/14/91	3	15:45	25	15	B	50	1.5	16.7	.5	8.4	.01	0.00	.01
9/14/91	3	15:45	25	15	B	25	1.5	16.7	.5	8.4	.07	.07	5.28
9/14/91	3	15:45	25	15	B	25	3.0	16.7	.5	8.4	.03	.04	2.64
9/14/91	3	15:45	25	15	B	75	1.5	16.7	.5	8.4	.03	.12	2.34
9/14/91	3	15:45	25	15	B	250	1.5	16.7	.5	8.4	.01	.10	1.05
9/14/91	3	15:45	25	15	B	75	1.5	16.7	.5	8.4	.03	.07	2.18

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[a] Bulk asbestos content in percent, determined by the mean of three composite samples of the road surface material.

[b] In percent

[c] Phase contrast microscopy measured asbestos concentration

of the samples respectively. Non-chrysotile structures including Antigorite generally occurred at a rate of about 1% of chrysotile structures.

3.3 METEOROLOGICAL CONDITIONS

Table 3-5 summarizes the meteorological conditions experienced each day of testing at each study site. Note that data recording for each day began upon site arrival, usually 9 to 11 A.M., and ended upon site departure, usually 5 to 7 P.M. Therefore these values represent highs, lows, and means of the meteorological parameters during this period, not true daily highs, lows, and means.

Table 3-6 summarizes the wind conditions experienced for each testing run at each study site. Items included are mean wind speed, mean wind direction, and standard deviation of wind direction.

Table 3-5. SUMMARY OF METEOROLOGICAL CONDITIONS MEASURED ON EACH STUDY DAY

Site No.	Date	Relative Humidity		Temperature		Avg. Wind Speed (m/s)	Avg. Wind Direction
		Low	High	Low	High		
1	8/19/91	38%	51%	81.4	89.3	4.0	298°
1	8/20/91	24%	49%	73.3	91.6	4.3	297°
1	8/23/91	37%	47%	80.7	92.9	3.4	275°
2	8/21/91	20%	44%	79.5	93.0	3.8	286°
2	8/22/91	29%	44%	82.1	91.5	3.9	295°
3	9/12/91	37%	53%	78.7	93.5	2.5	265°
3	9/13/91	41%	61%	74.0	91.1	2.4	273°
4	9/14/91	40%	53%	77.8	86.4	3.1	289°
4	9/15/91	51%	63%	74.1	85.7	2.4	283°

Table 3-6. SUMMARY OF WIND CONDITIONS MEASURED FOR EACH TEST RUN

Site No.	Test Run	Mean Wind Speed (m/s)	Mean Wind Direction	Standard Dev. of Wind Dir.
1	1	4.0	301	10.4
1	3	4.1	293	6.3
1	5	4.2	297	11.7
1	6	4.5	294	7.2
1	7	3.4	288	21.1
1	8	3.1	260	12.4
2	1	3.6	280	13.4
2	2	3.3	285	16.8
2	3	3.8	280	10.8
2	4	4.3	283	7.5
2	5	4.0	296	11.1
2	6	3.7	292	11.7
2	7	3.9	290	12.3
3	1	2.2	255	19.6
3	2	2.5	268	17.4
3	3	2.9	288	11.7
3	4	1.2	263	45.6
3	5	2.3	249	15.7
3	6	3.1	269	14.1
3	7	3.5	282	9.8
4	1	3.1	293	13.1
4	2	3.2	303	16.2
4	3	3.3	306	12.9

3.4 QUALITY ASSURANCE FOR AIR SAMPLES

To ensure that the field experiments would yield scientifically valid air samples, the following types of quality assurance data samples were taken:

(1) Four laboratory blanks and four field blanks to ensure that all filter cassettes used for air sampling were neither contaminated nor mishandled.

(2) A total of 12 air samples with no traffic on the test road segments (2 air samples at downwind distances of 25' and 75' and 1 at an upwind distance of 50', for each of the 4 study sites) to determine the spatial distribution of background asbestos concentrations.

(3) A total of 21 upwind air samples with traffic on the test road segments to determine the asbestos concentrations in in-coming wind.

(4) A total of 18 replicate air samples taken by a floating sampler that was collocated with one of the primary samplers at 1.5 m or 3.0 m above the ground in order to determine the reproducibility of ambient asbestos concentration measurements. Collocated sampler results are provided in Appendix A.

(5) Two distant air samplers at 1100 feet downwind at Site 2 for two 5-hour periods to determine the downwind extent of traffic-induced road dust.

As to the laboratory and field blanks, none of the blank samples were found to contain any structures above the detection limit of transmission electron microscopy. This provided assurance that the filter cassettes used in the field experiments were indeed not contaminated.

In addition to the quality assurance measures listed above, all results were further verified by checking the consistency of data and examining all anomalous values. Although some values were identified that did not meet expected patterns (e.g., run 3 at site 3 where the TEM0 concentration at 3m was higher than at 1.5m), none were judged to be outside the range of plausibility.

Table 3-7 provides comparisons of ambient asbestos concentrations under three background conditions and two test conditions:

Background Condition

- No traffic
- Upwind receptors with traffic
- Remote receptors with traffic

Test Condition

- Downwind receptors at 1.5 m with traffic
- Downwind receptors at 3.0 m with traffic

The table shows that mean concentrations under the three background conditions (0.022 - 0.032 struc/cc) are only about a hundredth of those under the two test conditions (2.11 and 2.43). Because of this extremely low asbestos concentration level, the three background conditions (i.e., no traffic, upwind and 1100 ft downwind with traffic) indeed were judged to provide background asbestos concentrations.

Concentration values listed in Table 3-7 are for TEM0 -- all structures having ≥ 3-to-1 aspect ratio regardless of size. More conventional TEM5 (structures greater than 5 micrometers with ≥ 3-to-1 aspect ratio) concentrations were an order of magnitude lower than TEM0 concentrations. Since TEM5 concentrations under the three background conditions were below or around the TEM detection limit, the background asbestos levels exemplified by those under the three background conditions were judged to be negligible as compared to asbestos concentrations of the two test conditions -- in immediate downwind area with considerable traffic.

Asbestos concentrations of each pair of two collocated air samples (i.e., "replicate" vs "primary") are compared in Figures 3-1 and 3-2. Figure 3-1 shows TEM0 concentrations of 18 replicate samples taken by the floating sampler and those of the corresponding primary samples taken at upwind (2 samples) and downwind (16 samples) locations. The near symmetric scatter around the 1-to-1 line in the figure indicates a good reproducibility of ambient asbestos measurement by our sampling and TEM analysis methods. Although there is moderate scatter (indicating some random error), no particular trend is present (indicating negligible systematic error). Figure 3-2 shows the same pairs of data for TEM5 concentrations. This figure also exhibits a symmetric scatter around the 1-to-1 line, indicating no biases in either the sampling method or the analysis method used.

Table 3-7. COMPARISON OF BACKGROUND ASBESTOS CONCENTRATIONS WITH DOWNWIND ASBESTOS CONCENTRATIONS.

Background (B)/ Test (T) Conditions	Sample Size	TEMO, struc/cc				
		min	max	median	mean	s.d.
B: No traffic (both upwind & downwind)	12	.009	.114	.019	.032	.033
B: Upwind w/ traffic	21	.009	.139	.010	.024	.030
B: Remote Sample (at 1100 ft) w/ traffic	2	.009	.035	n/a	.022	.019
T: Downwind at 1.5m above the ground w/ traffic	72	.009	14.200	1.314	2.434	2.864
T: Downwind at 3.0m above the ground w/ traffic	19	.047	6.642	1.380	2.109	1.850

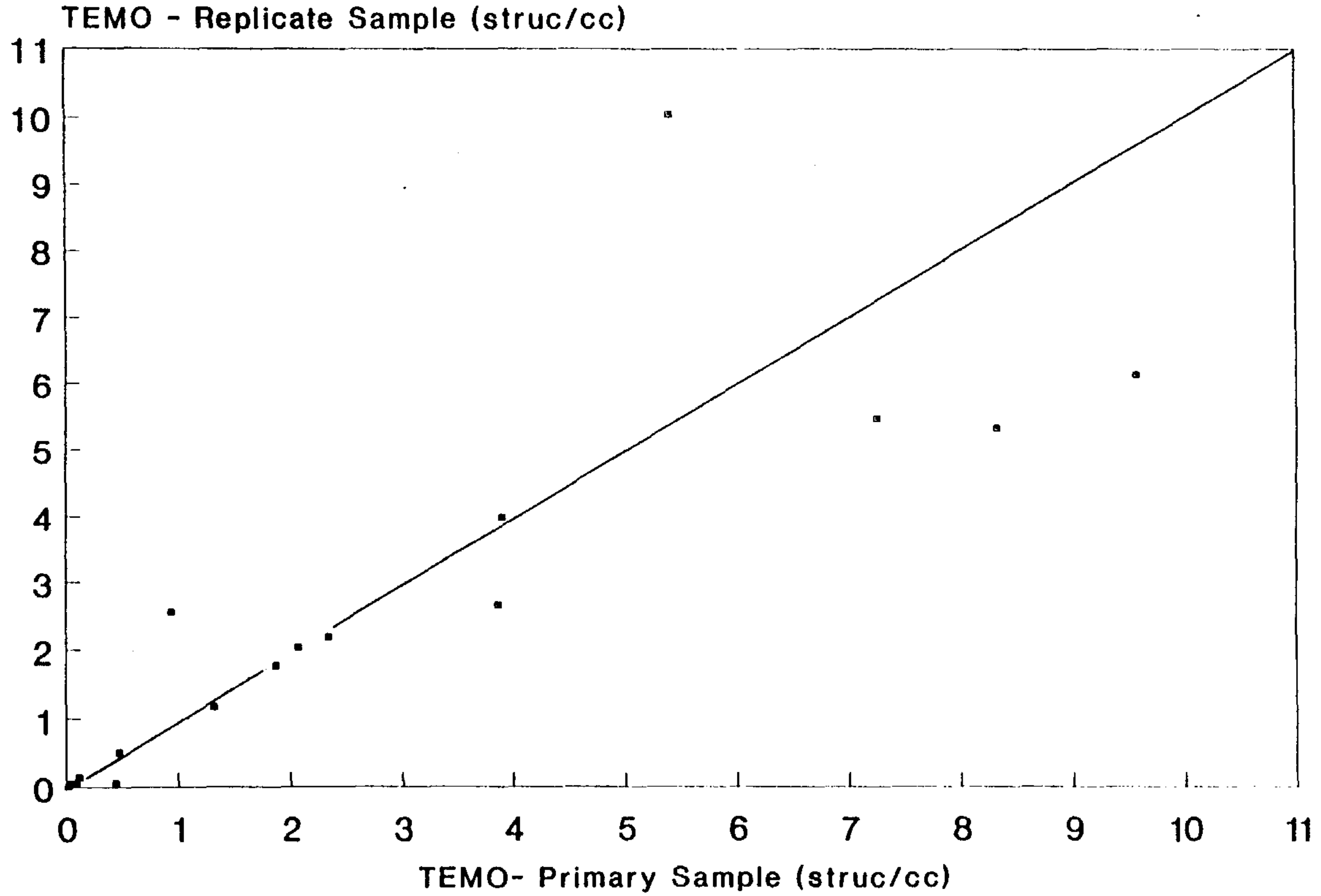

Figure 3-1. Comparison of TEM0 Asbestos Concentrations of Replicate Samples with those of Primary Samples (n = 18).

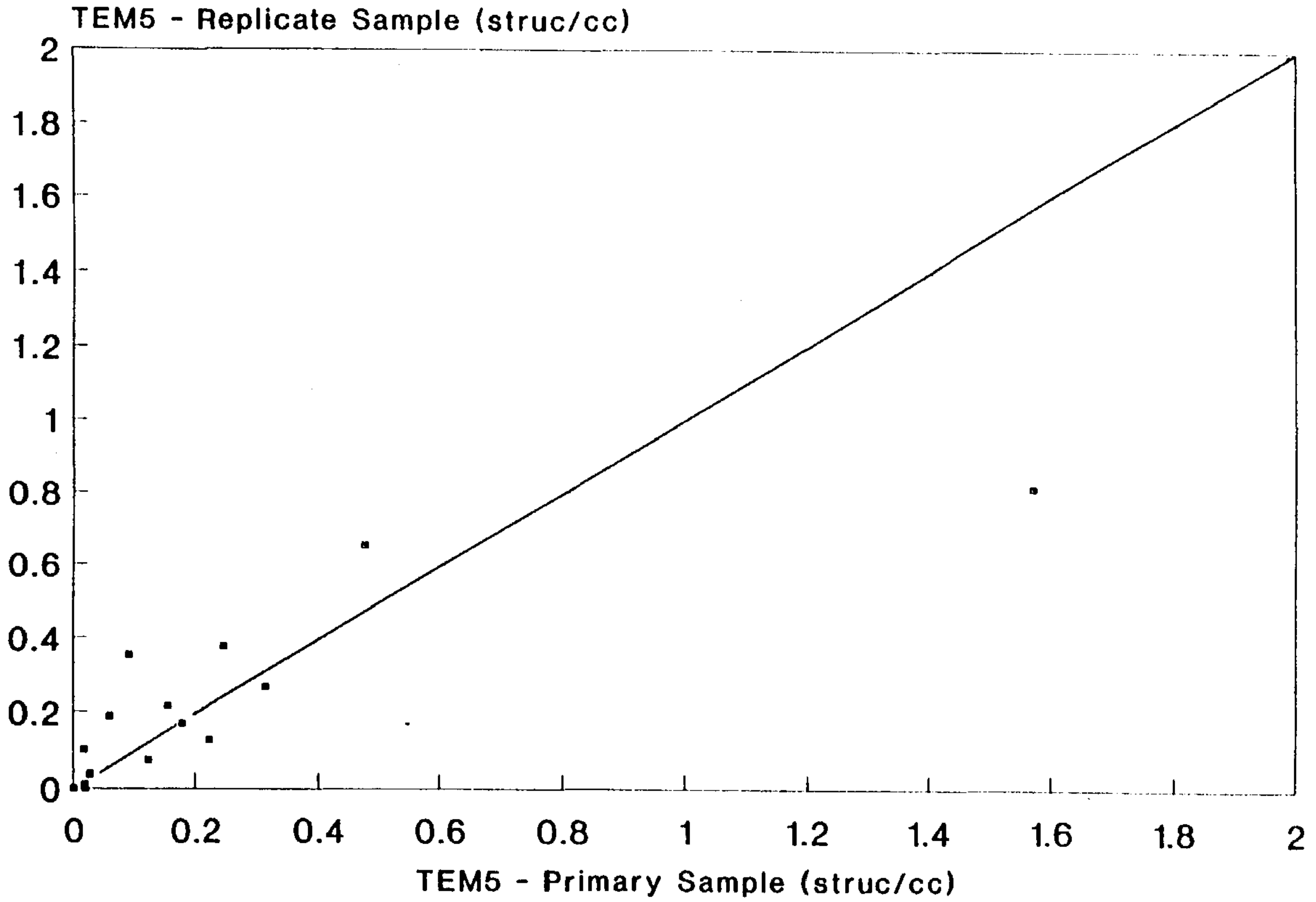

Figure 3-2. Comparison of TEM5 Asbestos Concentrations of Replicate Samples with those of Primary Samples (n = 18).

Figure 3-3 shows a scattergram of downwind (at 25 feet) asbestos concentrations at two different heights: 1.5 m and 3.0 m above the ground. It exhibits fairly high correlation between concentrations at 1.5 m and 3.0 m. To check whether the correlation exhibited in measured concentrations at 1.5 m and 3.0 m is reasonable, a theoretical ratio of concentrations at the two heights was computed according to the following equation:

$$\frac{A_{1.5}}{A_0} - \exp\left[-\frac{1}{2}\left(\frac{1.5}{\sigma_z}\right)^2\right] \qquad (3\text{-}1)$$

where $A_{1.5}$ is a theoretical concentration at 1.5 m above the ground, A_0 is a theoretical concentration on the ground, and σ_z is a vertical dispersions parameter. The reason for using 1.5 m and 0 m in the equation is that samplers at 1.5 m in the field experiment were presumed to represent virtual ground-level concentrations to which people are exposed.

Theoretical concentration ratios were computed using actual wind and stability conditions that existed at the 19 data points. Then, the theoretical ratios were compared with ratios of measured asbestos concentrations at 1.5 m and 3.0 m. Table 3-8 shows such comparisons. In general, the theoretical ratios of concentrations at the two heights are in good agreement with those calculated from measured asbestos concentrations. One noticeable difference between the theoretical and measured ratios is that the latter exhibit much wider variation in the ratio values than the theoretical ones.

Judging from the quality assurance data samples described hitherto, the field experiments seem to have generated reasonable scientific data of ambient asbestos concentrations around a serpentine-covered unpaved roadway.

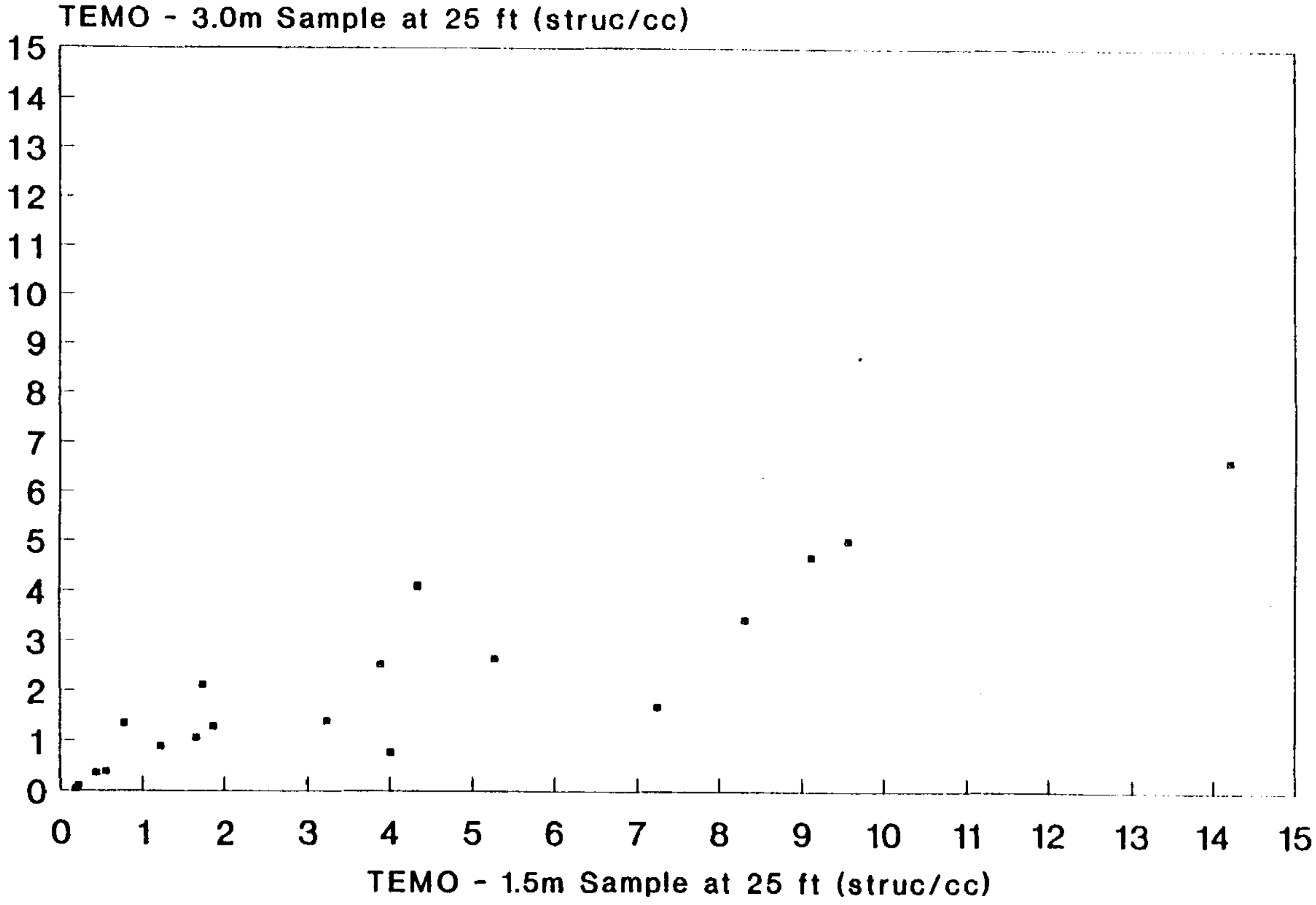

Figure 3-3. Downwind Asbestos Concentrations at 3.0 m and 1.0 m (n = 19).

Table 3-8. COMPARISON OF MEASURED RATIOS AND THEORETICAL RATIOS OF ASBESTOS CONCENTRATIONS AT 3.0 M TO THOSE AT 1.5 M ABOVE THE GROUND.

	Theoretical Ratio	Measured Ratio	
		TEM0	TEM5
Number of Cases	19	19	19
Minimum	0.34	0.19	0.00
Maximum	0.66	1.73	16.03
Median	0.61	0.52	0.47
Mean	0.57	0.64	1.39

4.0 EVALUATION OF EPA MODEL PERFORMANCE

4.1 COMPARISON OF MEASURED vs PREDICTED CONCENTRATIONS

As a preliminary step for evaluating and improving EPA's roadway asbestos concentration model, we compared asbestos concentrations observed in the field experiments with concentrations predicted by the model. The comparisons were made for two types of TEM-measured concentrations: TEM0 (total structures having ≥ 3-to-1 aspect ratios regardless of size) and TEM5 (structures ≥ 5 μm in length). These two number concentrations are reported as number of structures per cubic centimeter of air (struc/cc). The EPA model predicts number concentrations for structures ≥ 5 μm only, namely TEM5, which are considered to be PCM equivalent concentrations. PCM-based airborne asbestos exposure standards are given in Appendix B.

4.1.1 DESCRIPTION OF DATA SET USED FOR EVALUATION

Table 4-1 summarizes the number of TEM-analyzed air samples collected during the field experiments. The complete data set consists of 125 asbestos concentrations and corresponding sampler locations and traffic and weather conditions. This data set comes from test runs at all four study sites near Oakdale and excludes three test runs with unfavorable wind conditions.

Table 4-1. NUMBER OF ANALYZED ASBESTOS SAMPLES BY LOCATION[1]

Sample Location	Background	With Traffic
Downwind, 1.5m height	8	72[2]
Upwind, 1.5m height	4	21
Downwind, 3m height	0	20
Total	12	113

[1] Excluding field blanks, lab blanks, and distant samples.

[2] 64 of these above detection limit for TEM5.

Of the 125 data points, 12 are background samples and the other 113 represent samples taken during traffic simulation. Since the model does not predict concentrations in the absence of traffic, background samples were excluded from preliminary analyses. Of the 113 with-traffic samples, only the 72 samples located downwind at 1.5 m height were used for this analysis. This excludes 21 upwind samples and 20 downwind samples at the 3 m sampling height.

The final set of 72 samples includes samples collected at downwind distances of 25 ft., 75 ft., and 250 ft. from the center line of the test roadways. For use as model inputs, the actual distance travelled by the plume was calculated by dividing the sampler distance from the roadway by the cosine of the wind direction's deviation from the perpendicular path to the roadway using:

$$x = \frac{x'}{\cos(DEV)} \qquad (4\text{-}1)$$

Here x = distance travelled by the plume
x' = sampler distance from roadway
DEV = wind direction's deviation from perpendicular path

All 72 samples in the data set were used in TEM0 model analyses. However, 8 data points were excluded from the TEM5 model analyses because of concentrations below detection limits. The complete set including these 72 data points is given in Table 3-4.

4.1.2 COMPARISON OF RESULTS WITH EPA MODEL PREDICTIONS

Model calculations were performed using the EPA model, which is an expanded version of the Copeland Model that incorporates elements of a Gaussian line-source dispersion model and the original Copeland Model for dust emissions from unpaved roads:

$$A = 1.7\, k \frac{2}{(2\pi)^{0.5}} \frac{S}{12} \frac{V}{48} \left(\frac{W}{2.7}\right)^{0.7} \left(\frac{WH}{4}\right)^{0.5} \frac{AC}{100} \frac{n}{\sigma_z} \frac{CF}{U} \frac{365-p}{365} \qquad (4\text{-}2)$$

where A = TEM5 airborne asbestos concentration (struc/cc)
k = aerodynamic particle size multiplier
S = silt content of road surface (%)
V = vehicle speed (km/h)
W = vehicle weight (Mg=megagrams)
WH = number of wheels
AC = asbestos content of road surface (%)
n = vehicle frequency (no. of vehicle passes/s)
σ_z = vertical dispersion parameter (m)
CF = conversion factor (assumes 3×10^{10} struc/g of asbestos)
U = wind speed (m/s)
p = average number of days per year with $\geq$0.01 inches of precipitation

The vertical dispersion parameter σ_z was calculated using the equation:

$$\sigma_z = (\sigma_z'^2 + H^2)^{0.5} \qquad (4\text{-}3)$$

where H is an estimate of the initial vertical dispersion of the vehicle wake (in this case it was set to 1 m, or about half the vehicle height) and where σ_z' is calculated as:

$$\sigma_z' = A\, x^B + C \qquad (4\text{-}4)$$

where A, B, and C are constants as defined in Table 4-2.

Four model parameters were kept constant for all model runs. The average number of days per year with greater than 0.01 inches of precipitation was not known for Oakdale, so the value for Stockton (51 days) was used. The particle-size multiplier (k) was kept at the default value of 0.36, which is for particles $\leq$10 μm in accordance with AP-42. Vehicle weight was kept at 1.8 tons, which is the unladen weight of the test van. The number of wheels was kept at 4.

Table 4-2. CONSTANTS FOR VERTICAL DISPERSION PARAMETER

Stability Class	Distance ≤ 100 m			Distance > 100 m and < 153 m		
	A	B	C	A	B	C
A	0.192	0.936	0.0	0.00066	1.941	9.3
B	0.156	0.922	0.0	0.0382	1.149	3.3
C	0.116	0.905	0.0	0.113	0.911	0.0
D	0.079	0.881	0.0	0.222	0.725	-1.7
E	0.063	0.871	0.0	0.211	0.678	-1.3
F	0.053	0.814	0.0	0.086	0.740	-0.35

4.1.3 RESULTS OF THE COMPARISON

Figure 4-1 shows a comparison of model-predicted TEM5 concentrations vs measured TEM0 concentrations (all structures). The predicted concentrations are short of the measured concentrations by about an order of magnitude. Figure 4-2 shows the comparison using TEM5 data. This shows a better agreement in magnitude between predicted and measured concentrations, but exhibits a weaker association than that shown in Figure 4-1.

Figure 4-3 shows the comparison between model-predicted TEM5 concentrations and measured TEM5 concentrations at the two vehicle speeds used in the test runs. At 10 mph, the model overpredicts concentrations by about 300%, while at 25 mph the model-predicted and measured concentrations show reasonable agreement. Linear regressions were determined for the data shown in figures 4-1 through 4-3 in two ways: (1) with a non-zero intercept and (2) with a zero intercept. Regression statistics are given in Table 4-3. It should be noted that regressions with no intercept consistently perform better than those including an intercept. This implies that measured asbestos concentrations would be better explained by a multiplicative correction term to the EPA model rather than by an additive correction term.

Figure 4-4a shows the concentration profile of measured TEM5 airborne asbestos along downwind distance. Figure 4-4b shows the same profile for model-predicted TEM5

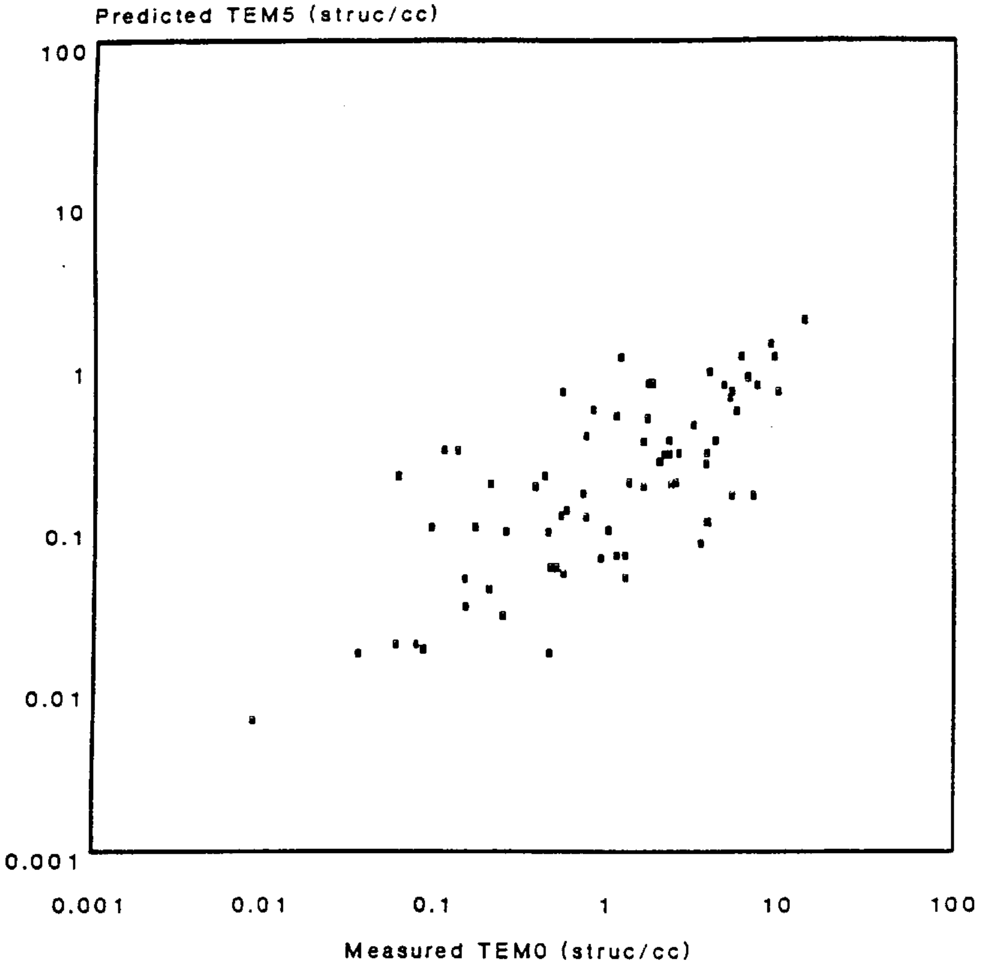

Figure 4-1. EPA Model Performance for Measured TEM0 vs Predicted TEM5 (n=72).

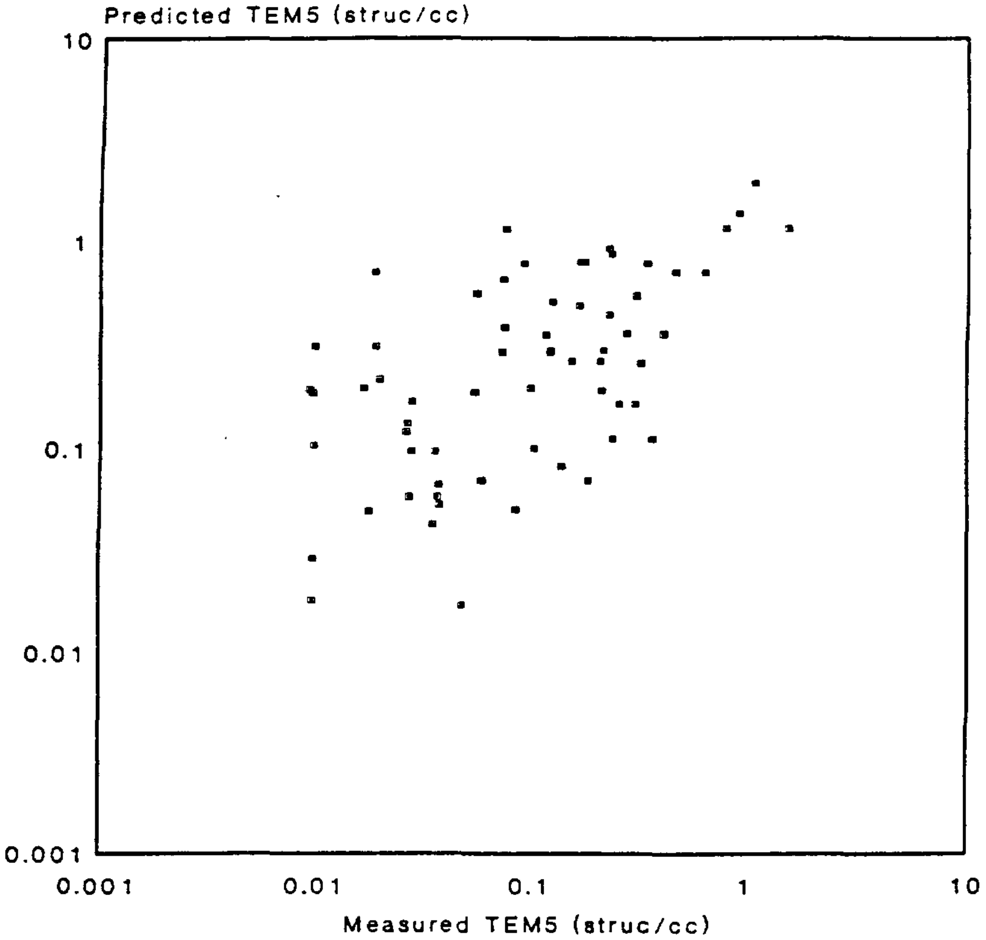

Figure 4-2. EPA Model Performance for Measured TEM5 vs Predicted TEM5 (n=64).

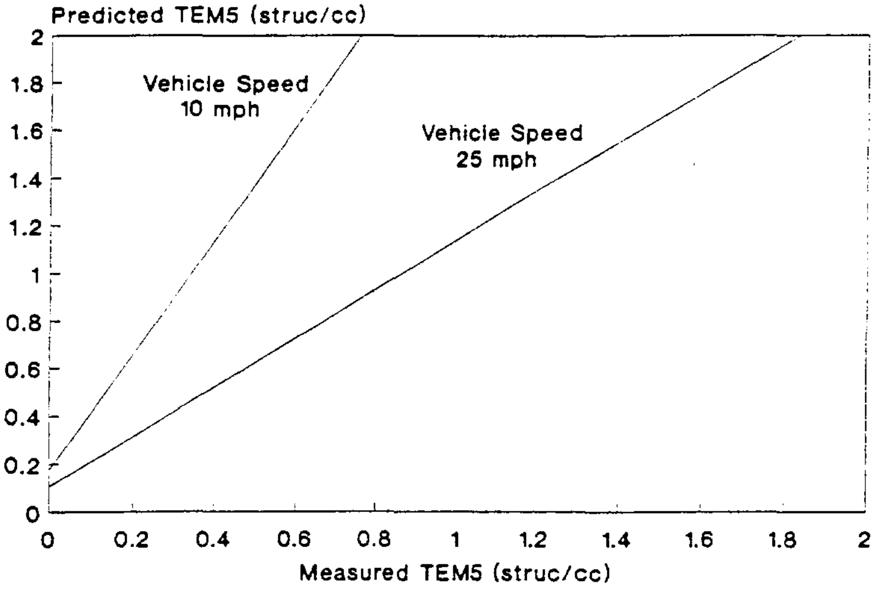

Figure 4-3. EPA Model Performance for Measured TEM5 vs Predicted TEM5 at 10 mph (n=25) and 25 mph (n=39).

Table 4-3. REGRESSION STATISTICS FOR EPA MODEL PREDICTED vs MEASURED ASBESTOS CONCENTRATIONS.

Figure	n	Dependent Variable	Independent Variable	Intercept	Slope	P-Value of Slope	Adjusted r^2
4-1	72	Predicted TEM5	Measured TEM0	0.105	0.097	<0.001	0.55
				—	0.115	<0.001	0.73
4-2	64	Predicted TEM5	Measured TEM5	0.185	0.961	<0.001	0.49
				—	1.275	<0.001	0.67
4-3	25 (10 mph)	Predicted TEM5	Measured TEM5	0.174	2.411	0.003	0.30
				—	3.627	<0.001	0.63
	39 (25 mph)	Predicted TEM5	Measured TEM5	0.108	1.030	<0.001	0.63
				—	1.193	<0.001	0.79

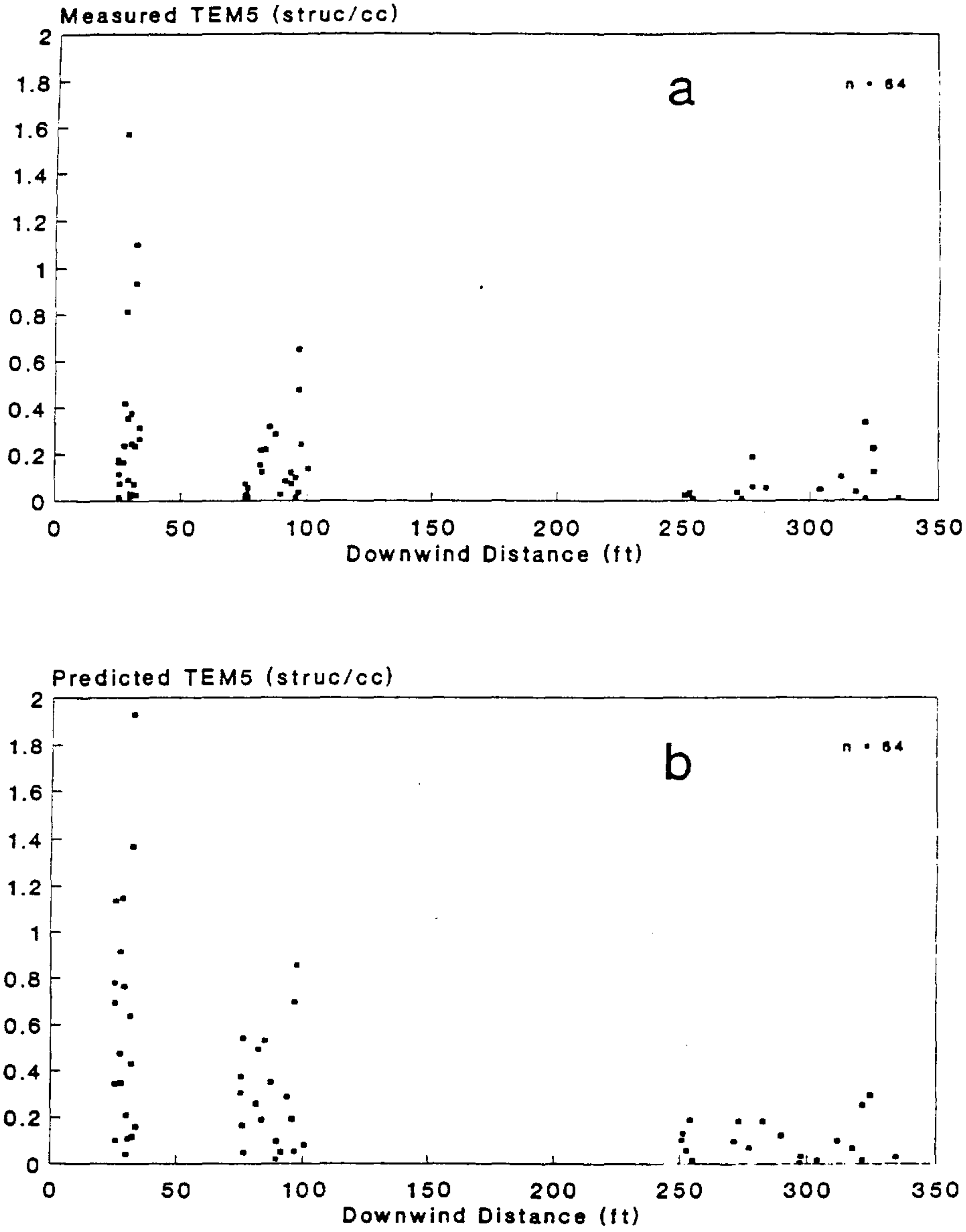

Figure 4-4. EPA Model Performance for Measured (a) vs Predicted (b) Profiles of Downwind Concentrations.

concentrations. The three clusters along the x-axis in each of the profiles represent the three downwind sampler distances of 25 ft., 75 ft., and 250 ft. corrected for wind direction according to Equation 4-1.

4.2 EVALUATION OF THE EPA MODEL STRUCTURE

The present EPA model for assessing asbestos concentrations downwind of an asbestos containing unpaved roadway consists of three model components:

(1) Particulate mass emissions from unpaved road;

(2) Dispersion of emitted asbestos containing particulate matters to downwind receptors; and

(3) Transformation of asbestos containing particulate matter into airborne asbestos fibers.

Using brackets to isolate each of these model components, respectively, the EPA model can be expressed as:

$$A = \left[n\ k\frac{S}{12}\frac{V}{48}\left(\frac{W}{2.7}\right)^{0.7}\left(\frac{WH}{4}\right)^{0.5}\left(\frac{365-p}{365}\right)\right]\left[\frac{2}{(2\pi)^{0.5}\sigma_z U}\right]\left[1.7\ \frac{AC}{100}\ CF\right] \qquad (4\text{-}5)$$

where A = TEM5 airborne asbestos concentration (structures/cc)
k = aerodynamic particle size multiplier
S = silt content of road surface (%)
V = vehicle speed (km/h)
W = vehicle weight (Mg=megagrams)
WH = number of wheels
AC = asbestos content of road surface (%)
n = vehicle frequency (vehicles/s)
σ_z = vertical dispersion parameter (m)
CF = conversion factor (assumes $3x10^{10}$ structures/g of asbestos)
U = wind speed (m/s)
p = average number of days per year with >0.01 inches of precipitation

The first component of the model is given by the Copeland Emission Factor model, which is said to be the best currently available model for particulate emissions from unpaved roadway. This is confirmed by personal communication with Mel Zeldin of SCAQMD and Drs. Charles Cowherd and Gregory Muleski of the Midwest Research Institute.

The only improvement that can be made on this emission factor equation would be to replace the last precipitation term with soil moisture content. As in the silt content, site-and test-condition specific soil moisture content will be a better parameter for hourly particulate emission rates than the annual number of days with measurable precipitation at a nearby NWS station.

The Gaussian line source dispersion model used in the second component also seems reasonable as evidenced by the similarity of downwind concentration profiles between the measured and model-predicted concentrations (see Figure 4-4).

The third component regarding the transformation of road surface material into airborne asbestos fibers appears to contain several unsubstantiated assumptions. The EPA model assumes that particulate mass emitted from unpaved road increases linearly with increasing vehicle speed as seen in the first component. It is also implicitly assumed that the number of asbestos fibers generated increases linearly with increasing vehicle speed. Although the first assumption seems reasonable, the second assumption does not seem to have been substantiated with any evidence.

4.3 ANALYSIS OF RESIDUALS

The robustness of a prediction model can be examined by plotting the residuals of model-predicted values less measured values against various model parameters. Figures 4-5 through 4-9 show such residual plots against five selected parameters of the EPA model: vehicle speed, traffic volume, asbestos content, moisture content, and silt content. In a residual plot, the model can be said to be robust with respect to a model parameter if residuals scatter randomly around zero at any value of the parameter. If the residual plot exhibits any trend over parameter values, then the model is said to be biased with respect to that parameter.

Figure 4-5 shows that the EPA model tends to overestimate asbestos concentrations at the lower vehicle speed of 10 mph. The EPA model was validated at 30 mph. Therefore, the

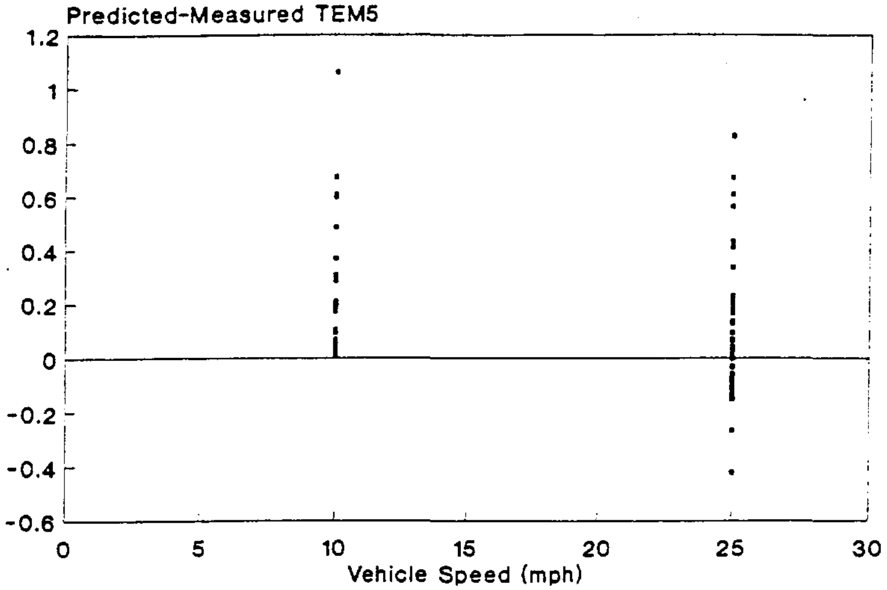

Figure 4-5. Residual Plot against Vehicle Speed.

model performance at 25 mph is quite good as evidenced by the even scatter of residuals around zero. The scatter pattern of residuals in this figure indicates that the number of asbestos structures generated by traffic on unpaved road increase more than linearly with vehicle speed. It can be interpreted that increasing vehicle speed not only increases particulate emissions but also generates more asbestos structures per unit of emitted particulate mass. Therefore, the number of airborne asbestos structures increases more than linearly with increasing vehicle speed. If this interpretation is correct, then the second assumption will turn out to be incorrect. Thus, the EPA model may need to be modified to reflect this fact.

Figure 4-6 shows that the EPA model tends to overestimate ambient asbestos concentrations at the two higher vehicle frequencies, 15 vehicles per hour and 45 vehicles per hour. Figure 3 shows that the model tends to overestimate at higher asbestos contents than 14 percent. Although these tendencies are difficult to explain as to the causes, appropriate correction terms to compensate the tendencies can be introduced to the model if the ARB wants such corrections.

Figures 4-7 and 4-8 show residual plots against bulk asbestos content and road moisture content, respectively. The EPA model, which instead of moisture content uses an annual average precipitation term that was held constant for this analysis, tends to overestimate ambient asbestos concentrations at higher road moisture contents. This is rather counter-intuitive because at the same location, the higher moisture content is expected to result in lower ambient asbestos concentrations. This can be explained by the limited number of sites tested, and the fact that the highest moisture contents happened to occur at the site with the highest bulk asbestos content (i.e., Site 3, see Table 3-4).

Figure 4-9 shows that the EPA model tends to overestimate ambient asbestos concentrations at the higher silt contents around 7.5 percent. The model assumes that asbestos concentrations increase linearly with increasing silt content of the road surface material. However, as with moisture content, silt content may have been coincidentally correlated with other road surface variables at the 4 sites, thus obscuring any direct relationship.

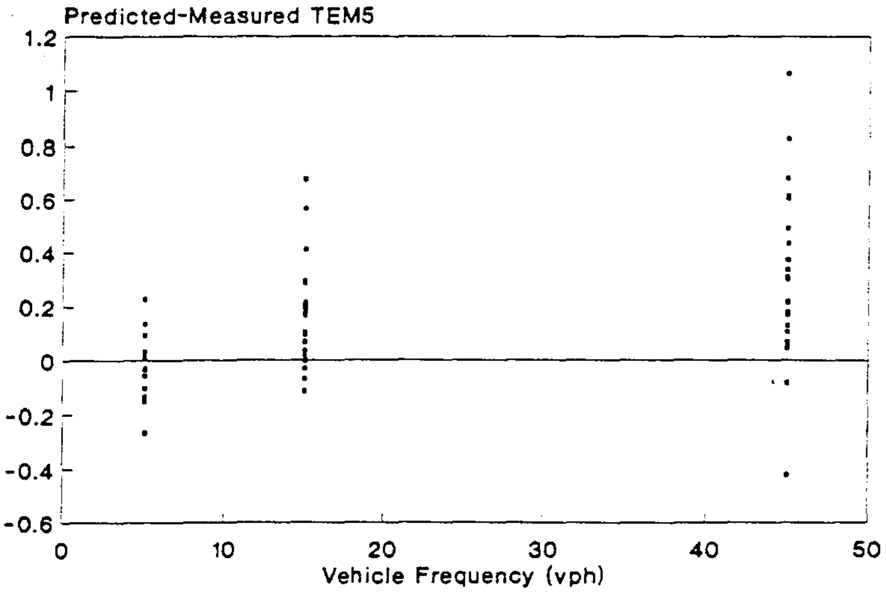

Figure 4-6. Residual Plot against Traffic Volume.

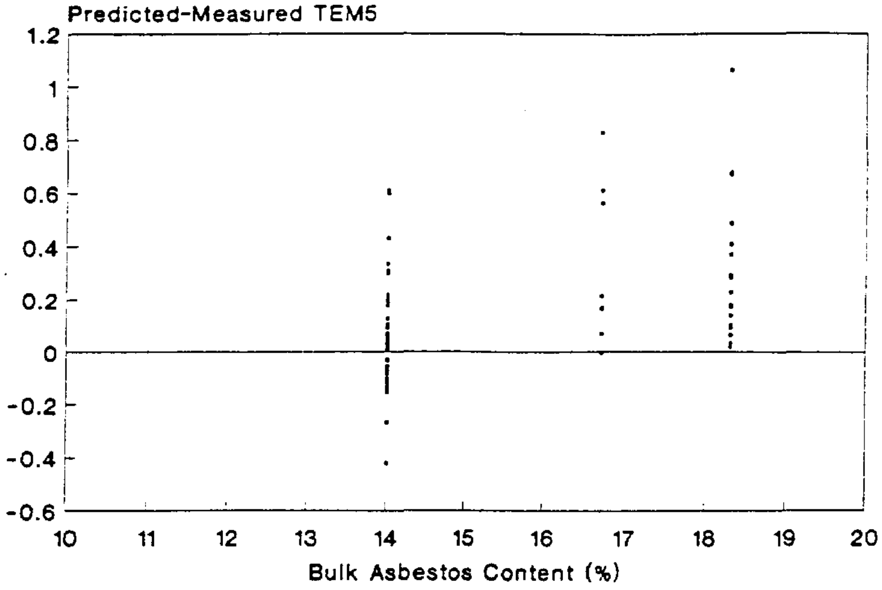

Figure 4-7. Residual Plot against Bulk Asbestos Content.

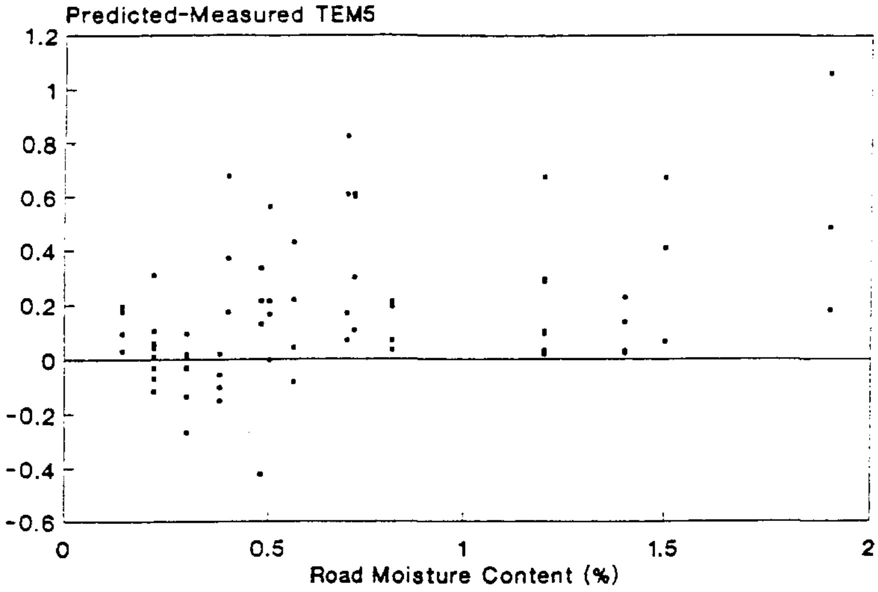

Figure 4-8. Residual Plot against Road Moisture Content.

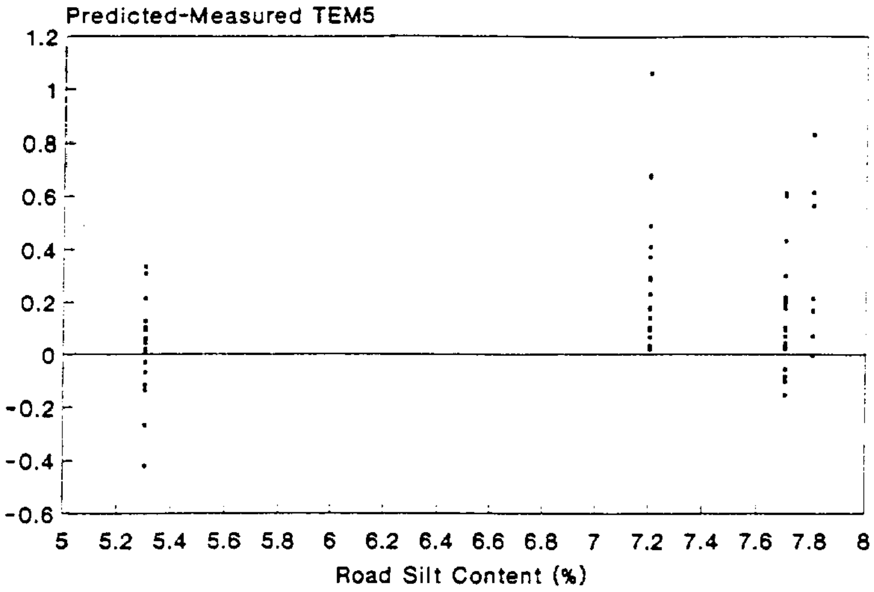

Figure 4-9. Residual Plot against Road Silt Content.

5.0 DEVELOPMENT OF MODIFIED ROAD MODEL

5.1 OBJECTIVES FOR MODEL IMPROVEMENT

The EPA model given by Equation (4-2) contains both a climatological parameter -- precipitation days -- and short temporal parameters such as the atmospheric stability and the dispersion coefficient. Although other model parameters such as vehicle speed, vehicle frequency, and wind speed can be either long-term (e.g., a year) averages or short-term (e.g., 1-hour) averages, the number of days per year with precipitation is by definition a long-term average. On the other hand, the dispersion coefficient and atmospheric stability are meaningful only for a time period of a few minutes to a few hours.

Because of the mixture of a climatological parameter and short temporal parameters in the same equation, the EPA model seems somewhat illogical in its current form. The model appears to be a product of a short-term model and an adjustment term for calculating a long-term average of the concentrations predicted by the short-term model. The precipitation days term of Equation (4-2) is indeed the adjustment term for long-term average concentrations under the following two assumptions;

(1) Road dust emissions arise only on days with no measurable precipitation; and
(2) The dispersion and traffic conditions remain the same over the period of interest.

The first assumption seems reasonable whereas the second assumption is more uncertain. Dust from the road will reach the receptor only while the wind direction has a component toward the receptor. Under most climatological conditions, this occurs less than 100 percent of the time.

As a predictive model, it should also provide the user an option of estimating short-term averages. For this purpose, the precipitation days term of the EPA model was replaced with a new model parameter for road surface moisture content that has proved to be useful for explaining an inverse relationship between dust generation and moisture content observed in the field experiments.

As described in the preceding section, the EPA model exhibits biases with respect to some model parameters. Thus it was a goal to reduce these biases by determining and applying a proper correction term to the EPA model. In addition, two additional features were considered important: a module to account for the effect of a finite road segment (instead of an infinite line source) on downwind concentrations; and a module to estimate short-term concentrations as well as long-term average concentrations.

5.2 DEVELOPMENT OF SHORT-TERM MODEL

To reduce the biases found in the EPA model evaluation (Section 4.0), a correction term, G, is explored in this section. For each of the 64 data points used in the model evaluation, G was calculated as:

$$G = \text{(Measured TEM5)/(Predicted TEM5)} \qquad (5\text{-}1)$$

where Measured TEM5 is the measured airborne asbestos concentration for structures $\geq 5\ \mu m$ and Predicted TEM5 is the airborne asbestos concentration predicted by the EPA model without the term for precipitation days (p). A series of multiple linear regressions were then calculated according to the equation:

$$\log G = b_1 \log X_1 + b_2 \log X_2 + ... + b_n \log X_n + \log C \qquad (5\text{-}2)$$

where b is the slope of the regression, X represents measured model parameters, and C is a constant. The regression was performed on several different combinations of variables such as vehicle frequency, vehicle speed, silt content, etc. The most plausible result was obtained from the use of vehicle speed and moisture content, as:

$$\log G = \log V - 0.6 \log M - 5.5 \qquad (5\text{-}3)$$

where V is vehicle speed and M is percent moisture content of the road surface. This equation explained about 48% of the variance in log G ($p < 0.001$) and was found to reduce 76% of the variance of the model prediction errors on the 64 data points. Thus an improved VRC model is written as:

$$[\text{VRC MODEL}] = [\text{EPA MODEL}] \times G \qquad (5\text{-}4)$$

$$= [\text{EPA MODEL}] \times 0.012 \times VM^{-0.6} \qquad (5\text{-}5)$$

or:

$$A - 1.7\,k\,\frac{2}{(2\pi)^{0.5}}\,\frac{S}{12}\,\frac{V^2}{48}\left(\frac{W}{2.7}\right)^{0.7}\left(\frac{WH}{4}\right)^{0.5}\frac{AC}{100}\,\frac{n}{\sigma_z}\,\frac{CF}{U}\,\frac{0.012}{M^{0.6}} \qquad (5\text{-}6)$$

This equation represents the short-term model for predicting hourly average concentrations for cases where some site-specific data on asbestos, silt, and moisture contents and on local wind conditions are available.

Figure 5-1 shows a scatter plot of the concentrations predicted by the VRC model vs measured concentrations. Although substantial scatter is still evident, it represents an improvement over the EPA model performance as shown in Figure 4-2. The VRC model explains 81% of the variance in the measured concentrations, compared to 67% explained by the EPA model.

5.2.1 DEFAULT VALUES

The computer code of the VRC model is designed to assign default values for all unspecified model parameters. The purpose of assigning default values is twofold:

(1) To provide a basis for sensitivity analyses and demonstration of the model.
(2) To provide model users with reference values.

In view of these purposes, default values should be selected to be as representative as possible of situations in which the model is likely to be used. Defaults were selected as follows:

> **Stability Class:** Stability class is an alphabetic categorical variable with a lookup table (Table 4-2) to calculate a dispersion parameter, σ_z. Though the neutral class D is used as a default in the EPA model, and indeed is the most likely typical stability class in the long term, it is not considered representative of atmospheric stability during peak traffic hours. Thus stability class B was selected as the default because it represents an intermediate stability during daylight conditions.
>
> **k-factor:** In accordance with AP-42, the default value for k is set to 0.36, which is the aerodynamic particle-size multiplier for particles ≤ 10 μm.
>
> **Silt Content:** The default silt content was set to 7%, which was typical of the 4 field experiment sites, all of which were moderately worn roadways.

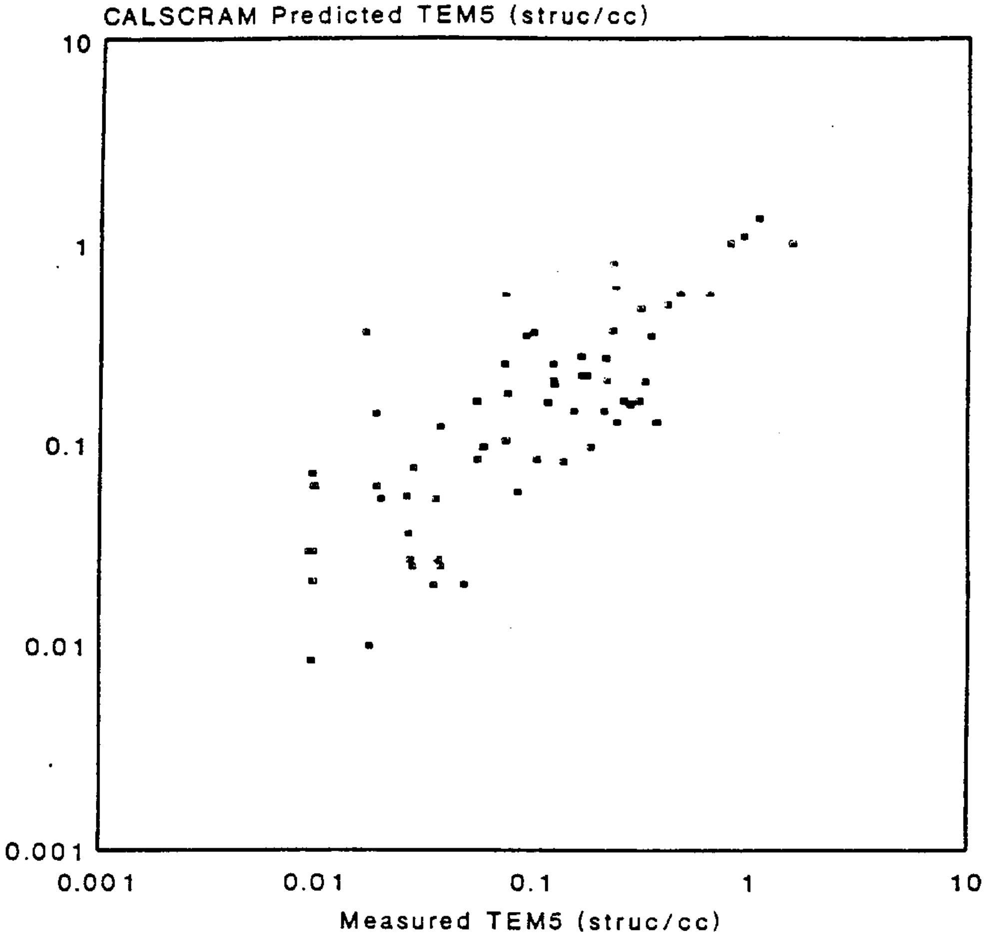

Figure 5-1. VRC Model Performance for Measured TEM5 vs Predicted TEM5 (n=64).

Vehicle Speed: The default vehicle speed was set to 25 mph, for reasons discussed in Section 2.2.3.

Vehicle Weight: The default vehicle weight was set to 1.8 tons, which is typical of a light truck or van.

Number of Wheels: The default number of wheels was set to 4.

Vehicle Frequency: The default vehicle frequency was set to 5 veh/h.

Asbestos Content: The default asbestos content was set to 10%, which is lower than typical asbestos contents in the Oakdale region where the field experiments were conducted, but may be more representative of serpentine-covered roads statewide.

H: The default value for H, the initial dispersion of the vehicle wake, was set to 1 m, which is roughly 50% of the height of a light truck or van.

Wind Speed: The default wind speed is set to 3 m/s, which is typical of wind speeds observed in the Oakdale area during the field experiments (mean wind speed for Stockton is 3.3 m/s; Fresno 2.8 m/s).

Moisture Content: The default value for road moisture content was set to 1%.

5.2.2 SENSITIVITY ANALYSIS

To determine model sensitivity to changes in model parameters, each input parameter was first decreased from default setting by 10% and then increased by 10% while all other input parameters were held at default levels. The mean deviation of the two resultant model outputs was then divided by the model output at default settings. Model parameters are ranked in Table 5-1 in descending order of the model's sensitivity to an equal percent change in these parameters. Sensitivity of the EPA model is shown for comparison. The model is most sensitive to changes in vehicle speed and least sensitive to changes in H. Since stability class is an ordinal variable and thus cannot be changed by a percentage as with other parameters, sensitivity of the model to changes in stability class as a function of downwind distance was separately computed (see Figure 5-2).

Table 5-1. MODEL SENSITIVITY

Parameter	Default Value	Sensitivity[a]	
		EPA Model	VRC Model
V	25 mph	10%	20%
k	0.36	10%	10%
S	7%	10%	10%
n	5 vph	10%	10%
AC	10%	10%	10%
U	3 m/s	10%	10%
d[b]	50 ft	7.3%	7.3%
W	1.8 tons	7%	7%
M[c]	1%	na	6%
WH	4	5%	5%
H[b]	1 m	2%	2%

[a] Sensitivity defined as the average percent change in output given a 10% increase or decrease in the value of the parameter at default conditions.

[b] Parameter sensitivity dependent on downwind distance, 50 ft in this analysis.

[c] Moisture content (M) is not included as a parameter in the EPA model.

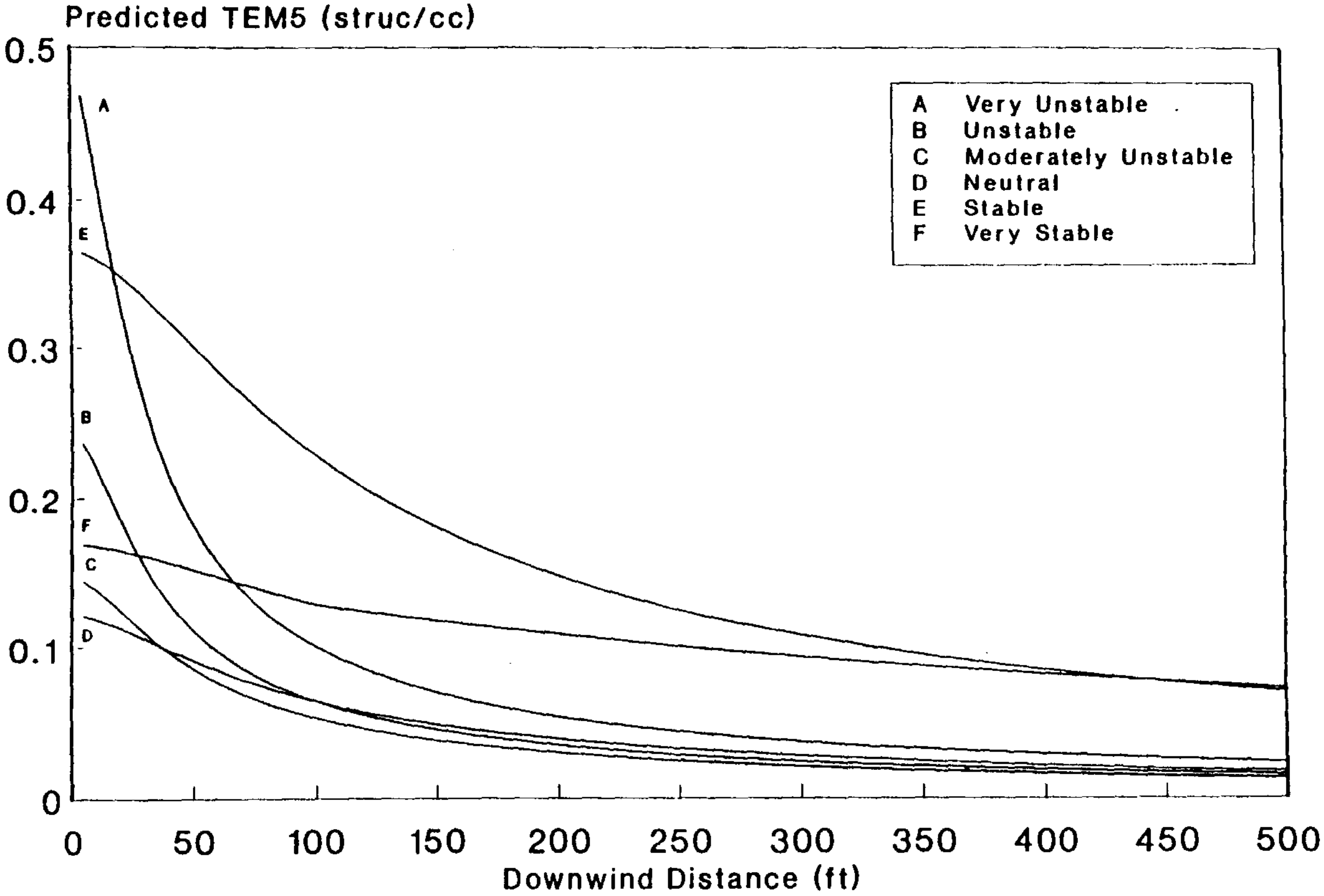

Figure 5-2. Asbestos Concentrations as a Function of Downwind Distance for Each Stability Class.

5.2.3 SHORT ROAD SEGMENTS

The EPA model is based on a line source dispersion equation given by Turner (1970). The equation assumes that the line source is infinite. This assumption has little impact on model predictions for longer road segments. However, in cases where the length of the road segment is less than about the distance from the road to the receptor, this will cause progressive overestimation with increasing distance from the road.

Turner (1970) also provides a correction term needed for short road segments which can be expressed as:

$$\frac{1}{\sqrt{2\pi}} \int_{p_1}^{p_2} e^{-p^2}\, dp \qquad (5\text{-}7)$$

where $p = y/\sigma_z$ and y is the lateral distance along the roadway. The values p_1 and p_2 are given for y = -L/2 and y = +L/2 where L is the length of the road segment. It is assumed that the receptor is directly downwind of the midpoint of the road segment, L.

Table 5-2 shows the effects of a finite road segment on downwind concentrations under various stability classes. The effects are most pronounced under A stability and the least under D stability.

5.3 DEVELOPMENT OF LONG-TERM MODEL

An easy-to-use long-term model was devised by introducing two adjustment terms to the VRC short-term model equation: climatological wind term and precipitation days term. The precipitation days term is the same as that of the EPA model, namely, (365-p)/365, where p is the number of days with 0.01 inches or more of precipitation.

The climatological wind term is introduced to account for receptor concentrations brought about by the wind blowing from several different directions over a year or other long period. Assuming that the emission rate remains the same over the period, a long-term average receptor concentration from the emission source is given by:

Table 5-2. EFFECT OF FINITE ROAD SEGMENT ON DOWNWIND CONCENTRATIONS.

Road Length (ft)	Downwind Distance (ft)	Downwind Concentration under Stability Class (struc/cc)			
		A	B	D	F
∞	50	.0636	.0519	.0424	.1517
∞	100	.0351	.0298	.0298	.1282
∞	500	.0082	.0072	.0082	.0504
200	50	.0635	.0518	.0424	.1515
200	100	.0350	.0297	.0297	.1280
200	500	.0069	.0068	.0082	.0504
50	50	.0627	.0514	.0424	.1506
50	100	.0309	.0281	.0296	.1280
50	500	.0023	.0027	.0059	.0487

Note: Wind speed set as: A - 2 m/s, B - 3 m/s, D - 6 m/s, F - 2 m/s

$$\frac{2Q}{(2\pi)^{0.5}} \sum_{i=1}^{8} \frac{f_i}{\sigma_{zi} U_i} \qquad (5\text{-}8)$$

where Q is the emission rate, f_i is the fraction of the time that wind blows from the i-th sector of the wind rose for the area, U_i is the average wind speed of the i-th sector wind, and i (=1 to 8) is one of the 16 sectors of 22.5 degrees in the wind rose which has at least some component blowing from the roadway to the receptor. The dispersion coefficient σ_{zi} is computed in the same manner as for the short-term model using the mid-direction of each sector wind. The value for downwind distance used to calculate σ_z is given by:

$$x_i = \frac{x}{\cos(DEV_i)} \qquad (5\text{-}9)$$

where x is the receptor distance from the roadway, x_i is the downwind distance corrected for wind direction, and DEV_i is the deviation of the mid-direction of the i-th sector wind from the perpendicular path of the roadway (see Eq. 4-1).

The long-term model is therefore expressed as:

$$A = 1.7\ kn\ \frac{S}{12}\ \frac{V^2}{48} \left(\frac{W}{2.7}\right)^{0.7} \left(\frac{WH}{4}\right)^{0.5} \frac{AC}{100}\ CF \frac{0.012}{M^{0.6}}\ \frac{15}{24}\ \frac{365-p}{365}\ \frac{2}{(2\pi)^{0.5}} \sum_{i=1}^{8} \frac{f_i}{\sigma_{zi} U_i} \qquad (5\text{-}10)$$

5.4 DEVELOPMENT OF COMPUTER PROGRAM

A computer program called CALSCRAM (California Serpentine-Covered Roadway Asbestos Model) was written and compiled for IBM PC* and compatible computers in Microsoft QuickBasic** for use as an efficient means of processing model calculations. The program allows users to either manually enter model inputs or, for users needing to process large numbers of cases, use comma-delimited ASCII data files for model inputs. A user's manual for the program is provided in Appendix C.

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* IBM PC is a registered trademark of International Business Machines Corporation.

** QuickBasic is a registered trademark of Microsoft Corporation.

6.0 REFERENCES

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APPENDIX A

Collocated Sampler Results

Table A-1. COLLOCATED SAMPLER RESULTS FOR SITES 1 AND 2.

Date	Run	Time Start	Veh. Speed (mph)	Veh. Freq. (vph)	Sampler Dist. (ft)	Sampler Height (m)	PCM5 (f/cc)	TEM5 (struc/cc)	TEM0 (struc/cc)
Site 1									
8/19/91	3	17:40	25	15	75	1.5	0.02	0.02	0.94
							0.01	0.10	2.56
8/20/91	5	14:28	25	5	25	1.5	0.05	0.32	7.25
							0.06	0.27	5.47
8/20/91	6	17:08	25	45	75	1.5	0.08	0.48	5.41
							0.07	0.65	10.04
8/23/91	7	12:35	10	15	25	1.5	0.01	0.02	0.44
							0.01	0.00	0.06
8/23/91		14:00	10	45	25	1.5	0.02	0.18	1.87
							0.01	0.17	1.76
Site 2									
8/21/91	2	14:40	25	45	25	1.5	0.09	1.57	9.57
							0.10	0.81	6.15
8/21/91	3	15:52	10	45	75	1.5	0.02	0.15	2.07
							0.01	0.22	2.04
8/21/91	4	17:10	25	15	250	1.5	0.01	0.06	1.31
							0.01	0.19	1.17
8/22/91	5	13:05	10	15	50up	1.5	0.01	0.00	0.01
							0.01	0.00	0.01
8/22/91	6	14:35	25	5	25	1.5	0.03	0.25	3.90
							0.02	0.38	3.99
8/22/91	7	15:55	10	5	75	1.5	0.01	0.00	0.08
							0.01	0.00	0.06

Table A-2. COLLOCATED SAMPLER RESULTS FOR SITES 3 AND 4.

Date	Run	Time Start	Veh. Speed (mph)	Veh. Freq. (vph)	Sampler Dist. (ft)	Sampler Height (m)	PCM5 (f/cc)	TEM5 (struc/cc)	TEM0 (struc/cc)
Site 3									
9/12/91	2	14:50	10	45	50up	1.5	0.01	0.00	0.03
							0.01	0.00	0.05
9/12/91	3	15:52	25	15	25	1.5	0.05	0.09	8.32
							0.05	0.35	5.33
9/13/91	4	12:12	10	15	75	1.5	0.01	0.02	0.11
							0.01	0.01	0.14
9/13/91	5	13:21	25	5	250	1.5	0.01	0.03	0.47
							0.01	0.04	0.51
9/13/91	6	14:28	10	5	25	3.0	0.01	0.00	0.05
							0.01	0.00	0.04
Site 4									
9/14/91	2	13:47	25	45	250	1.5	0.02	0.22	3.86
							0.03	0.12	2.66
9/14/92	3	15:45	25	15	75	1.5	0.03	0.12	2.34
							0.03	0.07	2.18

APPENDIX B

Current Airborne Asbestos Exposure Standards

The relationship between exposure to ambient levels of asbestos and health risk is a subject that includes many controversial and unresolved issues, such as the importance of differentiating among fiber types and sizes, the applicability of the original health data used to calculate cancer risks, and the extrapolation of high occupational exposures to low-exposure situatations. For further background on these issues, we strongly encourage the reader to consult the technical literature on asbestos-related health issues. However, for convenient reference, the following current exposure standards are presented:

Occupational Safety and Health Administration (OSHA)

Permissible airborne exposure limit for workers: 0.2 f/cc by PCM for fibers ≥ 5 µm, 8-hour time-weighted average.

Action level for asbestos in the workplace: 0.1 f/cc by PCM for fibers ≥ 5 µm, 8-hour time-weighted average.

National Institute for Occupational Health and Safety (NIOSH)

Standard for chrysotile asbestos: 0.1 f/cc by PCM for fibers ≥ 5 µm, 8-hour time-weighted average.

APPENDIX C

User's Manual for the CALSCRAM Computer Program

1.0 INTRODUCTION

The CALSCRAM program is intended to provide a cost-effective means for making preliminary estimates of airborne asbestos concentrations at receptor sites downwind of asbestos-containing serpentine-covered unpaved roads. At minimum, it requires the user to know the following information:

1. The bulk asbestos content of the road surface material, preferably as measured by ARB Test Method 435.
2. The silt content of the road surface material.
3. Typical traffic volume and patterns.
4. Typical wind speed and direction, and either typical number of days per year with 0.01 inches or more of rainfall, or the moisture content of the road surface material.
5. The downwind distance(s) of the receptor(s) of interest.

The user should also be familiar with each of the input parameters as listed in Table 1. Default values are provided by the program as a reference for users. Most input values are requested in English units (feet, miles, tons). These are internally converted to metric units by the program.

Model output is given as TEM5 asbestos concentration, which is defined as asbestos structures ≥ 5 µm in length as measured by transmission electron microscopy. The units are structures per cubic centimeter (struc/cc).

2.0 SETUP

The model was created in Microsoft QuickBasic and is designed to run on IBM PC or compatible computers operating under DOS 3.1 or later version. It is provided on a 3.5 inch floppy disk. It can be executed by either typing b:\CALSCRAM or by creating a subdirectory on a hard disk, copying the contents of the floppy disk to that directory, and typing CALSCRAM at the appropriate DOS prompt. Users should refer to a DOS reference guide if they are unfamiliar with the appropriate procedures.

3.0 EXECUTING THE PROGRAM

After an introductory screen, you are provided the option to quit the program or to continue with model implementation. There are two options for specifying input parameters: for on-screen input select 1; for file input select 2. If you are a first-time user and have not prepared an ASCII input file, select 1.

3.1 ON-SCREEN INPUT

The on-screen input option allows direct modification of input values while providing instantaneous model output. The output during manual input can be either case-specific (i.e., concentration averaged over a period of less than 3 hours) or long-term average concentration. The screen is initially set up for calculation of case-specific concentrations.

To modify input values or to activate model features, type the number associated with the parameter of interest at the prompt:

```
Select parameter to modify?
```

and hit enter. You will then be asked to enter a new value for the parameter. An explanation of each input parameter is provided below and in Table 1.

1. **Site ID:** The Site ID, which is optional, is user specified and does not affect estimates of airborne concentrations. It may consist of up to 8 characters.

2. **Stability Class:** The stability class (A, B, C, D, E, or F) is used to characterize atmospheric conditions that affect dispersion. Though the neutral class D is used as a default in the EPA model, and indeed is the most likely typical stability class in the long term, it is not considered representative of atmospheric stability during peak traffic hours. Thus stability class B was selected as the default because it represents an intermediate stability during daylight conditions.

3. **k-factor:** In accordance with AP-42, the default value for k is set to 0.36, which is the aerodynamic particle-size multiplier for particles ≤ 10 µm.

4. **Silt Content:** Silt content is the percent of the road surface material by dry weight that will pass a No. 200 sieve per ASTM Method D1140. The default silt content is set to 7%, which was typical of the 4 field experiment sites, all of which were moderately worn roadways.

5. **Vehicle Speed:** Vehicle speed is the average speed in miles per hour of all vehicles passing the subject road segment. The default vehicle speed is set to 25 mph.

Table 1. INPUT PARAMETERS FOR THE MODEL.

Input Parameter	Units	Default Value	Explanation
Site ID	none	none	User specified, up to 8 characters.
Stability Class	none	B	Atmospheric conditions (see Table #-#).
k	none	0.36	Particle size multiplier, as given by AP-42.
Silt Content	%	7	Percent of road surface material (by weight) passing a 200 Tyler mesh, measured by ASTM Method D1140
Vehicle Speed	mi/h	25	Average speed of vehicles traveling on subject road.
Vehicle Weight	tons	1.8	Average weight of vehicles traveling on subject road.
Number of Wheels	none	4	Average number of wheels of vehicles traveling on subject road.
Precipitation Days	days/yr	50	Number of days per year with 0.01 inches or more of precipitation. Sample values for California: Fresno 30, Red Bluff 70, Sacramento 57, Stockton 52.
Vehicle Frequency	veh/h	5	Average number of vehicle passes across subject road per hour.
Asbestos Content	%	10	Bulk asbestos content of road surface material, measured by ARB Test Method 435.
H	m	1	Initial vertical dispersion of the vehicle wake. At typical speeds, it is recommended that H be set to 50% of the average vehicle height.
Wind Speed	m/s	3	Average speed of wind blowing from the subject road toward the receptor.
Moisture Content	%	1	Percent of road surface material (by weight) that is moisture, measured by ASTM Method D2216.
Downwind Distance	ft	50	Distance from the road to the receptor, measured parallel to the prevailing wind direction.

6. **Vehicle Weight:** Vehicle weight is the average weight in tons of all vehicles passing the subject road segment. The default vehicle weight is set to 1.8 tons, which is typical of a light truck or van.

7. **Number of Wheels:** This is the average number of wheels of vehicles passing the subject road segment. The default number of wheels is set to 4.

8. **Vehicle Frequency:** The vehicle frequency is the average number of vehicle passes per hour over the subject road segment during the entire period of interest. The default vehicle frequency is set to 5 veh/h.

9. **Asbestos Content:** The asbestos content is the percent bulk asbestos content of the road surface material as determined by ARB Test Method 435. The default asbestos content is set to 10%. Typical asbestos contents for road surfaces consisting of mined serpentine rock in California are 5% to 15%.

10. H: H is the initial dispersion height of the vehicle wake. The default value is set to 1 m, which is roughly 50% of the height of a light truck or van.

11. **Wind Speed:** Wind speed is the average wind speed in meters per second. The default wind speed is set to 3 m/s, which is typical of wind speeds in much of California (some mean wind speeds for California: Bakersfield 2.9, Fresno 2.8, Red Bluff 3.9, Sacramento 3.7, and Stockton 3.3). This parameter becomes inactive if a long-term average is selected.

12. **Moisture Content:** Moisture content is the percent of the road surface material by dry weight that is moisture according to ASTM Method D2216. The default value for road moisture content is set to 1%. This parameter becomes inactive if a long-term average is selected.

13. **Downwind Distance.** Downwind distance refers to the distance in feet from the center of the roadway to the receptor. The downwind distance of the receptor is measured at its closest point to the roadway. The model is recommended to be used to determine case-specific concentrations only if the wind direction is within 45° of perpendicular to the roadway. If the wind is not perpendicular, the downwind distance must be adjusted by dividing the perpendicular distance by the cosine of the wind direction's deviation from perpendicular, thus giving the net travel distance of the induced dust from the road to the receptor. If you are determining a long-term average, the downwind distance is always measured along an axis perpendicular to the road orientation. The model then internally calculates the adjusted travel distance for each of the 16 wind sectors.

14. **Short Road Segment.** Since the basic model is based on an "infinite line source" assumption, it may overestimate concentrations for road segments that are less than about 1000 ft. Generally, the infinite line source assumption is reasonable if the receptor is closer to the road segment than the length of the straight road segment. To correct for a short road segment, enter "14" at the select parameter prompt. You will be asked to enter the length of the subject road segment. To return to a long road segment (i.e., infinite line source assumption), hit enter at this prompt.

15. **Long Term Average.** Long-term averages (e.g., annual averages) will generally be lower than short-term averages because of variable wind directions and precipitation. To estimate a long-term average, enter "15" at the select parameter prompt. Two selections will become available for modification: "Precipitation Days" and "Wind Sectors". These replace "Moisture Content" and "Wind Speed", respectively, which both become inactive. When estimating long-term averages, be sure that the vehicle frequency and other parameters are representative of the entire time frame. To return to a case-specific estimate, enter "15" at the select parameter prompt.

16. **Precipitation Days:** The precipitation days selection is activated for long-term averages only. Precipitation days are the number of days per year with 0.01 inches or more of precipitation. The default value for precipitation days is set to 50 (some mean precipitation days for California: Bakersfield 36, Fresno 34, Mount Shasta 90, Red Bluff 70, Sacramento 57, and Stockton 52).

17. **Wind Sectors:** The wind sectors option is activated for long-term averages only. Wind rose data will increase the accuracy of long term averages because of changes in wind speed and direction over time. The information required is the percent of time the wind direction falls under each of 16 wind rose sectors, the average wind speed for each sector, the road orientation, and the direction, perpendicular to the road orientation, of the receptor (receptor-normal direction). The first time you view the wind sector screen, the time percentages are filled with default values approximating the wind rose percents from Fresno. The wind speed is set to the default speed of 3 m/s. The road orientation is set to 90°, which is an east-west trending roadway, and receptor-normal direction is 180°, which means the receptor is on the south side of the roadway.

    By entering "17" at the select parameter prompt, you will access the wind sector screen. You will first be asked whether you wish make modifications to percent of time, wind speed, or road orientation (P, W, or R). At this prompt you can also return to the main screen by hitting enter. If you select P or W, you will be asked to first enter the sector for modification and then the new value. If you select R you will first be asked to enter the road orientation and the receptor-normal direction.

18. **Restore Defaults:** The restore defaults option allows you to delete all changes made during the on-screen input option and return all parameters to their default values. Default values for input parameters are listed in Table 1.

19. **Save Settings:** This option saves all current model inputs to a file. Note that only one test case can be saved in each file.

20. **Retrieve Settings:** This option retrieves from a file model inputs from previously saved test cases.

21. **Print:** This will produce a printout of the current case, including all model inputs and the output.

22. **Help:** Select this option for explanations of any of the input parameters or features in selections 1 to 21.

3.2 FILE INPUT

The file input option allows you to use an input file in comma-delimited ASCII format. The output can be sent to an output file, to a printer, or to the screen. Input files, which should be created within your database or spreadsheet software, must have the following comma-delimited fields:

1. Site ID	alphanumeric (up to 8 characters)
2. Stability Class	alphanumeric (A, B, C, D, E, or F)
3. k	numeric
4. Silt Content	numeric (%)
5. Vehicle Speed	numeric (mi/h)
6. Vehicle Weight	numeric (tons)
7. Number of Wheels	numeric
8. Vehicle Frequency	numeric (veh/h)
9. Asbestos Content	numeric (%)
10. H	numeric (m)
11. Wind Speed	numeric (mi/h)
12. Moisture Content	numeric (%)
13. Downwind Distance	numeric (ft)

The output during file input is "case-specific", which means that it is not averaged over 24 hours or annually. If the file input option is to be used to calculate long-term exposures, you must input typical or average values for each input parameter or, preferably, do enough model runs to represent the temporal variation in traffic and weather at the site and use the output to calculate a concentration averaged over the desired time scale.

Output can be sent to the screen, a printer, or a file by selecting S, P, or F at the output prompt.

Appendix E-4

United States Environmental Protection Agency
Diamond XX Road Study

EVALUATION OF RISKS POSED TO RESIDENTS AND VISITORS OF DIAMOND XX WHO ARE EXPOSED TO AIRBORNE ASBESTOS DERIVED FROM SERPENTINE COVERED ROADWAYS

FINAL

Prepared by:
ICF Technology, Inc.
1800 Harrison St.
Oakland, CA 94612

Prepared for:
The U.S. Environmental Protection Agency
Region 9
75 Hawthorne
San Francisco, CA 94104

May 24, 1994

1800 Harrison Street
Oakland, California
94612-2321

510/419-6000

ICF TECHNOLOGY INCORPORATED

May 25, 1994

Kira Lynch
P-3-2
United States Environmental Protection Agency
75 Hawthorne St.
San Francisco, CA 94104

RE: Work Assignment No. 59-06-D800 of Contract No. 68-W9-0059.

Dear Kira:

Please find enclosed seven bound copies and one unbound copy of our final report, "Evaluation of Risks Posed to Residents and Visitors of Diamond XX Who Are Exposed to Airborne Asbestos Derived from Serpentine Covered Roadways." Let me know if this is a sufficient number to circulate among the interested parties of EPA or if you would like additional copies for any other reason.

Note that one of the principle goals of this assessment was to reduce (or at least identify and evaluate) sources of bias to the estimated risks. If there is interest in reducing potential bias further, this can be accomplished by:

(1) performing a small number of additional paired analyses on archived samples (to improve the comparison between direct and indirect preparation);

(2) collecting a small number of additional road samples (dispersed throughout the community) and analyzing the samples to determine the distribution of asbestos in road material throughout Diamond XX;

(3) obtaining and evaluating historical wind data for the site to quantify the distribution of wind speed and direction prevalent at the site; and

(4) completing a site reconnaissance to determine the location of houses relative to the location of roads and the direction of prevailing winds.

Please call me if you have any questions or comments concerning this document.

Sincerely,

D. Wayne Berman, Ph.D.
Chief Scientist

cc Polly Quick (ICF Program Manager for ARCs)
Maria De La Cruz (ICF ARCs Contract Coordinator)

EVALUATIONOF RISKS POSED TO RESIDENTS AND VISITORS OF DIAMOND XX WHO ARE EXPOSED TO AIRBORNE ASBESTOS DERIVED FROM SERPENTINE COVERED ROADWAYS

FINAL

Prepared by:
ICF Technology, Inc.
1800 Harrison St.
Oakland, CA 94612

Prepared for:
The U.S. Environmental Protection Agency
Region 9
75 Hawthorne
San Francisco, CA 94104

May 24, 1994

TABLE OF CONTENTS

In September, 1993 the U.S. Environmental Protection Agency (EPA) conducted a series of experiments designed to provide measurements of the concentrations of asbestos in air generated downwind of serpentine-surfaced roadways during controlled traffic flow. The primary purpose of this study was to provide the data required to estimate risks experienced by residents living adjacent to such roads or who use such roads for transportation. The level of risk potentially experienced by children riding bicycles along these roads was a particular concern. This report presents a risk assessment performed using the data from the EPA experiments.

EXPERIMENTAL DESIGN

The September, 1993 study was conducted in a residential development known as Diamond XX, which is located off of Route 4 near Copperopolis, California. The experimental design of the study is described briefly below. A more detailed description of the design and procedures can be found in the Diamond XX Sampling and Analysis Plan (EPA 1993).

Based on a review of weather patterns and topography, two roads were selected, which:

- run reasonably straight for a required 300 ft;
- are clear of obstructions for several hundred feet lateral to the road in the vicinity of the selected study area; and
- run approximately perpendicular to the direction of prevailing winds.

At each roadway, sampling stations were set up on a line representing the perpendicular bisector to the 300 ft section of road that defines each study area. Stations were set at:

- 150 ft upwind;
- 25 ft downwind;
- 75 ft downwind; and
- 150 ft downwind.

Each station included a high-volume sampler to collect samples of total respirable dust and a low-volume sampler to collect samples suitable for asbestos analysis. Typically, additional sampling equipment was also set up at one station to collect duplicate samples. The station at which duplicate samples were collected was varied from experiment to experiment.

In addition to those set up in the study area, a sampling station was also typically established at a location remote from the study area and samples were collected at this remote station over the same time interval as specific experiments being conducted on the road. Measurements from these locations are intended to provide estimates of asbestos concentrations representative of remote background.

Sampling was generally conducted over a three-hour period during which a control vehicle was driven at constant speed (30 mph) back and forth at a fixed frequency (0, 5, or 15 vehicles per hour or vph) over the selected road. Experiments were conducted over the course of three consecutive days at each of the two roadway locations. Two separate runs were typically completed on each day.

A small number of sampling stations at various locations were also left to run overnight on specific evenings. Results from these measurements were designed to provide an estimate of the average concentrations of asbestos prevailing over the 12 hour period not evaluated during the main part of the study.

Wind speed and direction were monitored during each experiment to assure that conditions remained constant to within the defined tolerances of the study. The study was conducted during meteorological conditions that are believed associated with the greatest potential for asbestos release from the roads (i.e. dry and warm with steady winds blowing perpendicular to the road).

Samples of respirable particulate matter (PM10) were collected using a high volume sampler coupled to a size selective inlet per the requirements of EPA Reference Method RFPS-1287-063. The PM10 was collected during each run on 8-inch by 10-inch quartz filters and analyzed by gravimetry (i.e. the filters were weighed before and after sample collection and the difference in weights computed to provide a measure of the mass of respirable dust collected).

The airborne concentration of respirable dust at each station was determined by dividing the mass of dust captured by the volume of air passed through the quartz filter during each run. Additional details concerning the requirements for sampling respirable dust can be found in 40 CFR Part 50, Appendixes J (the reference method), and K -- "Interpretation of a National Ambient Air Quality Standard for Particulate Matter in the Atmosphere."

Due to the anticipated filter loading and a desire to improve the precision of the measurements, sample collection filters analyzed for asbestos were prepared using an indirect preparation technique (Chatfield and Berman 1990). However, because analytical results derived from directly prepared samples are believed by some researchers to relate better to available slope factors for asbestos, concentrations derived from the indirectly prepared samples of this study were converted to estimates of the equivalent concentrations to be expected from directly prepared samples using a conversion factor derived from measurements collected during the study.

To derive an appropriate conversion factor between indirectly and directly prepared samples, approximately half a dozen paired samples were collected with one filter of each pair prepared by the indirect technique and the other filter by a direct technique. Results of these paired analyses were then subjected to a regression analysis to determine the relationship between samples prepared by the different techniques. For a description and comparison of preparation techniques, see Berman and Chatfield (1990).

Filters were analyzed for the determination of asbestos using the counting and identification rules defined in the ISO method (Chatfield 1993). The stopping rules were modified so that sufficient asbestos structures would be counted to allow detection (with high probability) of the anticipated differences between upwind and downwind samples.

Asbestos concentrations are reported for each sample by each of four indices:

- a phase contrast microscopy equivalent (PCME) count defined to be consistent with the EPA "Asbestos Health Effects Assessment Update" (1986). This index is referred to as *PCME (EPA 1986)*;
- a PCME count .defined to be consistent with the California Proposition '65 definition of asbestos (California ARB 1986). This index is referred to as *PCME (Ca: Prop '65)*;
- an index recommended in a pending publication (Berman et al. 1994) that is currently being evaluated by the EPA. This index is referred to as the *B & C index* in the text; and
- a count of all structures longer than 5 μm (*total long structures*), which is an index recommended in an internal review document (Berman and Crump 1989) that is also undergoing review by the EPA. This index is designed to serve as a surrogate for the B & C index, which is much more difficult to measure.

The precise definition of each index and the manner in which each index is generated is presented in Appendix A.

The purpose for presenting asbestos concentrations expressed in each of four indices is to allow multiple interpretation of asbestos risk based on various published and soon to be published procedures. The procedures employed for evaluating the risks attendant to asbestos exposure remain controversial.

The resulting measurements from the set of experiments conducted at Diamond XX were subjected to analysis of variance (ANOVA) to determine what factors potentially affect the level of airborne asbestos generated by vehicular traffic on serpentine-covered roads. Estimated average exposure concentrations appropriate for a specific set of exposure scenarios were also derived from the data and combined with corresponding slope factors to provide an estimate of risk potentially experienced by the following specific populations:

- residents in houses immediately adjacent to the roads;
- children who bicycle regularly along the roads; and
- individuals exposed continuously to concentrations typical of background.

RESULTS

A total of 65 sample filters were prepared by the indirect technique and analyzed to derive estimated airborne asbestos concentrations at specific sampling stations during specific runs. These include 12 pairs of duplicate samples (with paired filters collected immediately adjacent to the each other). Four filters representing laboratory blanks and seven filters representing field blanks were also prepared and analyzed. Five additional sample filters (each paired with one of the other sample filters described above) were also collected, prepared by a direct technique, and analyzed.

Because the concentrations measured on field blanks and lot blanks are small relative to the smallest field concentrations measured, it is assumed that contamination is not a problem and the blanks are not considered further except to document the concentrations measured.

Concentrations calculated for each asbestos filter sample collected during the study are provided in Appendix B. A key is also provided in this appendix that indicates the location and the conditions of the run during which each sample was collected.

The data were validated. A summary report of the results of data validation is presented in Appendix C.

ANOVA Results

Analysis of variance (ANOVA) is a formal statistical procedure that evaluates the degree to which the variability of particular dependent variables can be attributed to the effects of one or more independent variables. As applied here, the utility of the ANOVA is two-fold. First, it is a sensitive procedure for testing whether two or more sets of measurements are significantly different (i.e. for determining whether two or more measurable quantities are distinguishable). Second, it provides strong evidence for causal relationships between dependent and independent variables (i.e. for determining whether specific parameters affect the processes being studied). Thus, for example, ANOVA can be used to determine whether changes in wind speed or vehicle frequency (independent variables) affect the rate at which asbestos is released and transported from a serpentine-covered road (the dependent variable).
The ANOVA conducted on the asbestos concentrations measured in this study were performed similarly for each of the first three indices of concentration defined in the last section. The fourth index, total long structures, was added later to facilitate risk estimation by serving as a surrogate for the B & C index, but was not included in the ANOVA.

The ANOVA was conducted to determine the effect of the following parameters on measured airborne asbestos concentrations:

- sections of *roadway* (two were studied);
- *grossproximity* (i.e. remote background versus all other stations near the road);
- *station* (i.e. the specific sampling location upwind or downwind with respect to the road);
- *vehicle frequency* (i.e. the number of passes per hour conducted by the control vehicle);
- *day* (i.e. the specific day on which the experiment was run);

- *sample number* (i.e. the specific filter number; used to distinguish among pairs of filters analyzed as duplicates); and
- *test number* (i.e. the numerical identifier of specific analyses; used to distinguish among pairs of analyses for each laboratory QC re-count).

The parameters, *sample number* and *test number,* were included to provide an indication of the irreducible variability inherent in the sampling and analysis of asbestos for this study; these represent the variability introduced by sample handling, laboratory handling, and analysis of filters. All of the other parameters were included to examine their effect on airborne asbestos concentrations.

Note that the parameter, *day*, was included to serve as a surrogate for general meteorological conditions; although weather patterns were reasonably stable over the entire 10 days of the study, the relationship between airborne concentration and *day* was examined to highlight any effects due to the small changes in meteorology that did occur during the course of the study.

When an ANOVA is performed, it is also generally possible to examine the potential "interaction" between the variables being evaluated. For example, in the ANOVA conducted for the Diamond XX study, the following interactions were also evaluated:

- roadway and gross proximity;
- station within roadway and gross proximity;
- vehicle frequency within roadway and gross proximity;
- station and vehicle frequency;
- sample number within all of the other parameters (except test number); and
- test number within all of the other parameters.

The degree of interaction between two (independent) variables indicates the extent to which the effects of two the variables on a third (dependent) variable are dependent on one another. For example, testing for the interaction between *roadway* and *gross proximity* provides an indication of whether the differences noted in concentrations between stations close to the road and those remote from the road are different for the two roadways studied.

When a specific parameter is examined "within" other parameters, what is being evaluated is the effect that the specific parameter has on a particular variable while "removing" (i.e. accounting for) the effects of the other parameters. For example, evaluating *test number* within all of the other parameters studied in this ANOVA provides an indication of the variability in measured asbestos concentrations that is attributable solely to the variability inherent to sample analysis (i.e. it is a measure of the average variability expected of duplicate analyses of the same filter).

A more detailed discussion of the ANOVA conducted for Diamond XX is provided in Appendix D. The implications of the ANOVA that are relevant to risk estimation for Diamond XX are discussed below.

As expected, the effect of both *station* (i.e. location relative to the road) and *vehicle frequency* (i.e. the rate of traffic flow) on measured asbestos concentrations are highly significant. Interestingly, there also appears to be a significant interaction between *station* and *vehicle frequency*. This means that the differences between downwind concentrations that can be attributed to changes in the rate of traffic flow are a function of the specific location (downwind) at which the asbestos concentrations are measured. It is not immediately clear why this is so.

When the control vehicle is traversing the road, a strong trend is noted in which asbestos concentrations decrease as a function of distance from the road and there are significant differences between the asbestos concentrations measured at specific downwind stations (i.e. at locations that are different distances downwind from the road). However, possibly because some of the downwind stations were located too close to each other, not all of the differences between stations are significant; while concentrations measured at 25 ft downwind of the road are always significantly different and higher than concentrations measured at 75 ft or 150 ft, concentrations measured, respectively, at 75 and 150 ft are not significantly different. Still, the concentrations measured at both the 75 and 150 ft downwind stations are always significantly higher than concentrations measured upwind.

Somewhat surprisingly, upwind concentrations measured 150 ft from the road are significantly different (and lower) than concentrations measured at remote background locations. This may be due, however, to what appears to be a single, high outlier among the concentrations measured at one of the remote locations[1].

Concentrations measured downwind of the road when the control vehicle is traversing at 15 vph are significantly higher than concentrations measured when the control vehicle traversed the study area at only 5 vph. However, concentrations measured when the traverse rate was 5 vph are only significantly higher than when no vehicles traversed the roadway for measurements expressed using either the PCME (Ca: Prop '65) or the PCME (EPA 1986) indices. For the measurements expressed in terms of the B & C index, concentrations measured when the control vehicle traversed the study area at 5 vph are *in*distinguishable from concentrations measured when there was no traffic on the road. When no vehicles were traversing the road, upwind and downwind concentrations are indistinguishable.

Interestingly, variation in measured asbestos concentrations as a function of *day* is not significant. Therefore, it should be valid to extrapolate the results of this study from the time period over

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[1] Measurement of elevated asbestos concentrations at a remote location can potentially be attributed to any of several possibilities including, for example, chance selection of a location that is proximal to an unidentified asbestos source or, more simply, contamination of one of the sample filters during handling or transport. Interestingly, when the single high value is removed from the set of measurements from remote locations, they become indistinguishable from the set of upwind measurements.

which the study occurred to other days, at least for days exhibiting meteorological conditions similar to those that prevailed over the interval during which the study was conducted.

Differences between asbestos concentrations measured during similar runs at each of the two road segments studied are not significant. Therefore, because the two road segments also appear to exhibit comparable asbestos concentrations[2], the data from this study cannot be used to assess the relationship between the concentration of asbestos in road material and the rate of asbestos release from such material. At the same time, this conclusion suggests that it should be valid to extrapolate the results of this study to other roadways exhibiting similar asbestos concentrations, provided that the other characteristics of the roadway that potentially control asbestos release (e.g. asbestos concentration, size distribution, moisture content, etc.) are also similar.

In summary, it is clear that individuals who live adjacent to the downwind edge of serpentine-covered roadways may be at elevated risk (compared to general background) due to increased asbestos exposure. Similarly, individuals who use such roadways for transportation (or recreation) may also be at increased risk. Both sets of risk may increase as a direct function of the frequency of traffic on such roadways. Note, although not tested formally in this study, it is also expected that risk will increase with increasing average speed of the vehicles traversing the roadway.

Risk Analysis Results

Risks potentially experienced by individuals visiting or residing at Diamond XX were estimated by evaluating mean airborne asbestos concentrations prevalent in the area. This was accomplished by converting such estimates to account for differences between direct and indirect preparation, combining the concentration estimates with estimates of the duration and frequency of exposure appropriate to specific receptors, and multiplying the resulting dose estimate by an appropriate slope factor.

Estimating Exposure Concentrations

The raw concentrations derived from the asbestos measurements collected during the Diamond XX study, which are presented in Appendix B, were combined to provide estimates of the mean concentrations relevant to specific station locations. Based on the ANOVA results presented in the previous section, it is valid to average the measurements collected at each station over day and road for each combination of station and vehicle frequency over which the study was conducted.

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[2] The concentrations of asbestos in road material were measured in this study using a new, soon to be published method (Berman and Kolk 1994), which is designed to provide high precision measurements that can be related to risk. Using this method, asbestos concentrations measured in road material for both roadways are on the order of 5×10^7 s/g when expressed as PCME (EPA 1986), 5×10^7 s/g when expressed as PCME (Ca: Prop '65), and 5×10^5 s/g when expressed in terms of the B & C index.

Table 1 is a summary of the mean concentrations of asbestos measured under specific conditions during the Diamond XX study. Values are presented, respectively, for a location that is 150 ft upwind of the road and for locations that are 25, 75, and 150 ft downwind of the road for runs conducted at either a vehicle frequency of 15 or 5 vph. Mean concentrations are also presented for runs in which the vehicle frequency was zero (i.e. no vehicles traversed the road), although all downwind distances are pooled for this case (i.e. concentrations are *not* presented as a function of distance downwind). Mean concentrations are also presented that are representative of remote background and of all-night samples. Note that concentrations are expressed using each of the four concentration indices defined as described in previous sections and Appendix A.

Concentration estimates derived from field blanks are also presented in Table 1 for comparison. Note that, to provide estimated concentrations for field blanks that would be comparable to the actual measurements, it was assumed that the average volume of air passed through the sample filters during the Diamond XX study also passed through the field blanks; this is simply a hypothetical construct designed to normalize the blank concentrations.

In general, the trends that are apparent among the concentrations presented in Table 1 have been shown to be significant, as discussed in the last section. Thus, among other things concentrations downwind of a roadway being traversed by traffic are significantly higher than upwind concentrations (see last section).

Concentrations measured upwind while traffic is traversing the road are comparable to the pooled concentrations measured when no vehicles are traversing the road. These concentrations are also comparable to the upwind concentrations measured at night. However, downwind concentrations measured at night appear to be greater than any of the upwind (or no vehicle) concentrations. This is not surprising because observations indicate that local residents use the road at night to get to or from their respective residences (Ecology and Environment 1993). Thus, there is some frequency of traffic that occurred during the time that the all night samples were collected and this contributed to airborne asbestos concentrations measured downwind of the road[3].

Due to the similarity of measured concentrations for all upwind samples and the no vehicle samples, it is likely that such concentrations are representative of local background. As indicated previously, although the mean concentrations estimated for remote background are *significantly* higher than this (based on the ANOVA described above), this mean appears to be skewed by a single high outlier (Appendix B). If this single outlier is removed, the mean concentrations measured for remote background become comparable to the "upwind" concentrations and the concentrations measured downwind during the no vehicle runs.

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[3] Wind patterns at night in the area of Diamond XX tend to be unsteady, unlike the stable patterns that tend to occur during the day. Therefore, the locations defined as "upwind" and "downwind" in the daytime may not be as clearly distinguished at night. Nonetheless, the pattern of asbestos concentrations measured at these locations during the night do suggest consistency with the patterns observed during the day.

Interestingly, the mean concentrations representative of the upwind and no vehicle samples that appear to be representative of local background are nonetheless higher than those measured for field blanks. This suggests that measurable asbestos concentrations exist in the air at Diamond XX whether or not traffic is generating asbestos releases from the roads. Such asbestos may derive from any of a variety of sources including, for example, remote sources of asbestos or wind-entrained releases from the local road.

Before the concentrations presented in Table 1 can be employed to derive estimates of risk, two additional issues need to be resolved. First, as indicated previously, because concentrations presented in Table 1 are derived from samples prepared by an indirect technique and the available slope factors for asbestos have been derived from samples prepared by a direct technique, it is necessary to convert the "indirect" concentrations to "direct" concentrations. Second, the duration and frequency of exposure to the specific receptors of interest must be defined and addressed.

Considering the Effects of Direct and Indirect Preparation

Table 2 presents the small set of paired samples from this study that were prepared, respectively, by a direct and an indirect technique (for a comparison of such techniques, see Berman and Chatfield 1990). The ratios of the direct and indirect pairs are provided at the bottom of the table. Unfortunately, careful analysis of these ratios revealed no significant correlation. Therefore, all that might be said about the conversion factor based on this table is that it likely lies somewhere between 2 and 25 (for all indices of exposure other than the B & C index).

It is possible (though unlikely) that the true conversion factor between direct and indirectly prepared samples lies outside the range indicated in Table 2. Unfortunately, the sample size employed to test the relationship between direct and indirect preparation in this study is apparently too small to provide the definitive result. However, the uncertainty attributable to the error potentially associated with this conversion factor is expected to be small relative to other sources of error typical of a risk assessment.

All of the risk calculations described below incorporate the extremes of the range of conversion factors presented in Table 2 (i.e. 2 and 25) and a middle value of 8.

Exposure Scenarios

The second issue that must to be resolved before risks can be estimated from this study is the need to define the characteristics of exposure that are appropriate for specific populations of interest. The first page of Table 3 presents a summary of several exposure scenarios believed relevant to the Diamond XX site.

The first case involves children bicycling on the serpentine-covered roads at the site. For this scenario, it is assumed that the mean concentrations from the closest downwind location (25 ft) are representative of the levels of exposure to which such children would be exposed. It is further assumed that such children may ride along the roads for an average of 7.3 hours per day (shorter during the school day and longer on weekends) and that they may continue such activities for 9 years. It is also assumed that such exposure would continue for 310 days of the year.

The value 310 is derived by subtracting from 365 the 15 days typically assumed for a family vacation (EPA 1991) and 40 days during which at least 0.01 inches of precipitation fall in the Diamond XX area during which exposure is expected to be nil (Army Corp of Engineers 1993).

A second scenario involves residents who may live by the road and are assumed to occupy their houses during the day. It is assumed that asbestos concentrations at such a house might be represented by the mean concentrations estimated for the location 150 ft downwind of the road. It is further assumed that such exposure continues for 12 hours per day, 310 days per year, for 30 years. A similar scenario is also presented for which exposure is assumed to continue for only 9 years.

A third scenario involves residents who may live by the road and are assumed to occupy their houses only during the night. The only difference between this scenario and the previous one is that the representative concentration for this case is now assumed to be the mean downwind concentration measured from the all night samples. Both a 9-year and a 30-year case are included for this scenario as well.

In the next set of rows in Table 3, the all-day resident and the all-night resident scenarios are summed to provide a 24-hour resident scenario.

Finally, the risk to individuals exposed continuously to mean background concentrations in the Diamond XX area are also evaluated both for a 9-year and a 30-year case.

Risk Estimates

On Pages 2 through 4 of Table 3, estimates of risk are provided for each of the various receptor populations defined on the first page of the table. Estimates are provided based on published slope factors appropriate to each of the three exposure indices carried through the analysis. Risk estimates were not derived for the B & C index because it was decided that the measurements of this index are too variable when measured via published methods and, therefore, such risk estimates would be too uncertain. Risk estimates are included, however, for an index representing total long structures, which serves as a surrogate for the B & C index. Note that a range of three estimates are provided for each exposure index and each case, which reflects the range of factors estimated as described previously for converting between indirectly and directly prepared samples. The three estimates incorporate, respectively, conversion factors of 2, 8, and 25.

Risk estimates are provided separately for two carcinogenic end points: lung cancer (Page 2 of the Table 3) and mesothelioma (Page 3 of the Table 3). Risks to smokers and non-smokers are presented separately. Note there are no risk estimates for smoking children since it is assumed that children generally do not smoke. Total carcinogenic risks (based on the sum of lung cancer risk and mesothelioma risk) are presented on Page 4 of Table 3. Sources of slope factors employed in Table 3 and a detailed description of other assumptions employed in the risk estimates are provided on Page 5 of Table 3.

Lung Cancer Risks. Comparing across rows on Page 2 of Table 3, it is apparent that, despite the very different estimates of concentrations derived using each of the various exposure indices

(Table 1) and the very different slope factors (Page 5 of Table 3), risks for lung cancer estimated across exposure indices are quite close.

With the exception of the low estimate for PCME (Ca: Prop '65), the estimates of risk for lung cancer across exposure indices appear to vary by no more than a factor of 3 with the long structures providing the highest estimates of risk (based on the model presented in Berman and Chatfield 1989) and the PCME (EPA 1986) index providing the lowest estimated risks. However, this excludes the "low" estimates of risk associated with the PCME (Ca: Prop '65) index, which are approximately an order of magnitude lower than risk estimates assigned to either of the other exposure indices. These relationships hold across all rows in the table (i.e. across all specific exposure scenarios).

From Pages 1 and 2 of Table 3 it can also be determined that selection of the appropriate factor for converting between directly and indirectly prepared samples may alter estimates of risk by more than an order of magnitude (i.e. this factor potentially contributes as much as a factor of 10 to the uncertainty of the risk estimates). However, the range of uncertainty introduced by this factor is fully captured in the table by incorporating three estimates of risk for each combination of exposure scenario and exposure index that are derived using each of three conversion factors: 2, 8, or 25.

Among non-smokers, risks of lung cancer to children who bicycle along the roadways in Diamond XX for 9 years are comparable to the risks for full time, 30-year residents and represent the highest set of risks estimated among non-smokers. Lung cancer risks to 30-year residents who smoke are estimated to be approximately an order of magnitude greater than the risks to non-smokers.

Risks for lung cancer estimated among non-smoking full-time, 30-year residents living downwind of a serpentine-covered road are approximately 40 times greater than what might be expected due to exposure to local background concentrations of asbestos. A similar elevation in risk is found among resident smokers who live downwind from a road in comparison to the risk they might expect from exposure to background. For 9-year bicyclists, this risk is approximately 100 times what might be expected due to background.

Mesothelioma Risks. Trends in the risks of mesothelioma estimated for the various receptor populations and presented on Page 3 of Table 3 are similar to those discussed for lung cancer above and the incremental increase in the risk of contracting mesothelioma appears approximately comparable to the estimated increase in the risk of contracting lung cancer among smokers.

For any particular exposure scenario (i.e. across any row of Page 3 of Table 3), it appears that the relative estimates of mesothelioma risk assigned to each exposure index vary by no more than a factor of 3, if the "high" estimates for PCME (Ca: Prop '65) are ignored. The "high" estimates for the PCME (Ca: Prop '65) index are approximately a factor of 5 greater than the estimates of mesothelioma risk assigned to the other exposure indices. The risk of contracting mesothelioma due to asbestos exposure is believed to be independent of smoking habits.

Interestingly, in contrast to estimates for lung cancer, the Total Long Structure exposure index is associated with the lowest relative risks for contracting mesothelioma among the three exposure indices presented in the table. This is because the model from which the slope factors are derived for this exposure index (Berman and Crump 1989) incorporates consideration of fiber type and the chrysotile structures common at the Diamond XX site are believed to be less potent toward the induction of mesothelioma relative to the induction of lung cancer than other mineral types of asbestos.

In parallel with the trends noted for lung cancer, the relative mesothelioma risks estimated for bicyclists exposed to road dust are approximately 100 times greater than those estimated in association with exposure to background asbestos concentrations. Full-time, 30-year residents living immediately downwind of a road potentially experience an approximately 40-fold increase in mesothelioma risk over what might be attributed to background.

Overall Cancer Risks. When risks for the induction of lung cancer and mesothelioma are combined (to generate overall cancer risks), trends among the various scenarios are similar to those observed when lung cancer risks and mesothelioma risks are considered separately. Thus, for example, full-time, 30-year residents living downwind of an asbestos-containing road potentially experience an increase in risk of a factor of 40 over what might be attributed to background exposure. Similarly, the estimated combined cancer risks to 9-year bicyclists exposed to road dust are about 100 fold greater than what might be expected due to exposure only to background asbestos concentrations.

When lung cancer and mesothelioma risks are combined (to generate an overall cancer risk), differences between risks to smokers and to non-smokers become much smaller than the order of magnitude difference in risks to these two groups when lung cancer is considered separately. This is because contributions to the overall risk from mesothelioma are the same to non-smokers as to smokers and because mesothelioma risks contribute at least half of the combined total risk in most cases. For smokers, mesothelioma risks contribute approximately half of total cancer risks. Among non-smokers, most of the total cancer risks can be attributed to contributions from mesothelioma while their risks for lung cancer are relatively small. For the same exposure scenario, the combined, total cancer risk to smokers and non-smokers differ by no more than a factor of four.

If all of the assumptions listed in Table 3 are valid, then the highest risks potentially attributable to exposure to asbestos from road dust are on the order of 10^{-2}. Continuous exposure to background asbestos concentrations in the Diamond XX area yields maximum risks on the order of 10^{-4}.

UNCERTAINTY

The estimates of risk provided in this document must all be interpreted carefully. Although an attempt was made to incorporate consideration of most of the many factors contributing to uncertainty in these estimates, it is difficult to quantify the degree of bias that may or may not be associated with such estimates.

It is likely that the risk estimates presented in this document are conservative. This is largely because: the frequency and duration of exposure estimated for each scenario are likely on the conservative side of the range of reasonable values[4], the estimates of slope factors are typically designed to be conservative, and the exposure indices employed in this document are designed to be conservative. Regarding exposure indices, for example, the use of total long structures (longer than 5 µm) as a surrogate for the even longer structures likely to contribute most to asbestos risk provide an overestimate of the number of such structures in a particular sample. However, because the slope factor employed with the Total Long Structure exposure index to estimate risks in this document partially addresses this over-counting (see Berman and Crump 1989 and Berman et al. 1994), the bias introduced by this last factor is probably limited.

Other factors that potentially contribute to the degree that the risk estimates in this document are conservative include distance from asbestos-containing roads and the concentration of asbestos in road material. The exposure estimates for residents provided in Table 3 assume that the resident spends their time within 150 ft downwind of an asbestos-containing road. However, very few houses in the Diamond XX area lie entirely (or even partially) within 150 ft of a road. It is likely, though not entirely assured, that the concentration of asbestos in the material of the road segments studied are among the highest concentrations to be found in the Diamond XX area. To the extent that such concentrations are higher than average, the risk estimates will be conservative.

Several factors relating to meteorology may contribute to the overall uncertainty of the estimates provided. For example, the concentrations estimated from the field study are causally associated with only a very narrow set of conditions that may represent only a very small fraction of the range of conditions that can occur throughout the year. Thus, if winds blow in different directions than that which prevailed during the study, if wind speeds are significantly higher or lower, if the relative humidity is vastly different, or even if temperature differs, exposure concentrations may be significantly higher or lower than what was in fact measured. Although precipitation was at least partially accounted for by assuming zero exposure on days with at least 0.01 inch of precipitation, there was no attempt to adjust for variation in wind speed or direction and these factors may be equally important in determining airborne asbestos concentrations.

Despite the above, the positive bias introduced into this risk assessment is likely *smaller* than those of other risk assessments typically conducted under Superfund for two reasons:

1. the estimates of airborne asbestos concentrations employed in this risk assessment were selected to be representative rather than conservative; and

2. the slope factors defined for asbestos (although controversial) are derived primarily from human epidemiology data rather than animal studies (see Berman and Crump 1989) so that they have not been subjected to the kinds of conservative treatments typically performed when animal studies are used to derive slope factors for humans.

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[4] Although the duration and frequency estimates employed in this risk assessment are likely to be conservative, it should be noted that they represent direct estimates provided by residents living in Diamond XX.

Note also that most of the contributions to uncertainty listed above are greatly mitigated when comparing among relative risks instead of estimating absolute risks. All of these factors should be considered if risk management decisions are to be developed based on the conclusions of this study.

Importantly, most of the sources of positive bias discussed above (other than those relating to the cancer slope factors for asbestos) can be eliminated, if a field reconnaissance is conducted during which historical wind data are collected and evaluated, houses are located relative to prevailing winds and roads, and additional road samples are collected and analyzed for asbestos.

CONCLUSIONS

The highest risks attributable to exposure to asbestos that is released from Diamond XX roads by vehicular traffic that were estimated in this study are to two different populations:

- full-time, 30-year residents who are smokers and who live downwind of an asbestos-containing road; and
- children who live in the area for at least 9-years and who bicycle along asbestos-containing roads.

Based on this study, the best estimate of the level of risk experienced by such individuals are on the order of 1 x 10^{-3} for both groups, with the estimates of risk ranging between 10^{-4} and 10^{-2}. Such absolute risk estimates are uncertain, although it is more likely than not that they are somewhat conservative.

Less uncertain are the relative risks estimated in this document. Full-time, 30-year residents who reside within 150 ft downwind of a roadway (whether they are smokers or non-smokers) likely experience an incremental increase in risk due to exposure to asbestos in road dusts that is approximately 40 times what they would experience if they were exposed only to background asbestos concentrations.

Similarly, children who reside in the area for 9 years and who bicycle frequently along asbestos containing roadways may experience risks that are elevated by 100 fold over what might be attributable to exposure to background concentrations of asbestos.

TABLES

TABLE 1
AVERAGES OF CONCENTRATIONS MEASURED FOR SPECIFIC LOCATIONS DURING THE DIAMOND XX STUDY

	Mean Concentrations (s/cc)(a):			
	PCME (EPA 1986)	PCME (Ca: PROP '65)	B&C INDEX	TOTAL LONG STRUCTURES
15 Vehicles per Hour				
Location A:	2.26E-03	6.82E-04	4.45E-06	4.66E-03
Location D:	3.04E-01	6.66E-02	7.88E-03	4.89E-01
Location C:	3.96E-01	8.09E-02	4.97E-03	6.63E-01
Location B:	1.40E+00	3.96E-01	3.10E-02	2.44E+00
5 Vehicles per Hour				
Location A:	3.25E-03	8.62E-04	1.03E-05	5.17E-03
Location D:	4.79E-02	2.31E-02	3.86E-04	1.02E-01
Location C:	6.53E-02	1.41E-02	1.40E-04	1.06E-01
Location B:	1.91E-01	5.99E-02	4.19E-03	3.33E-01
All Night Samples				
Upwind	3.70E-03	1.88E-03	1.05E-05	5.68E-03
Downwind	1.54E-01	4.82E-02	5.38E-03	2.79E-01
No Vehicles per Hour	8.41E-03	3.80E-03	9.08E-05	1.81E-02
Distant Background	6.29E-02	1.50E-02	1.53E-04	1.02E-01
Field Blanks	4.85E-04	6.06E-05	6.41E-07	Not Estimated

KEY:
Concentrations presented in this table represent arithmetic averages for groups of measurements representing each case.

Location A: 150 feet upwind of road
Location B: 25 feet immediately downwind of road
Location C: 75 feet downwind of road
Location D: 150 feet downwind of road

On different nights, all night, downwind samples were collected at different downwind stations that were different distances from the road.

The no vehicle per hour run concentrations are averaged over multiple distances downwind of the road.

(a) Concentrations were derived from samples prepared by an indirect technique.

TABLE 2
AVAILABLE ANALYSIS OF PAIRED DIRECTLY AND INDIRECTLY PREPARED SAMPLES (a)
(Units are in s/cc)

Sample Number	Sample Type	PCME (EPA 1986)	PCME (Ca: PROP '65)	B&C INDEX	TOTAL LONG STRUCTURES
From directly prepared samples:					
SY8564	R1-5DP-1B	1.85E-02	1.87E-03	3.18E-03	3.30E-02
SY8577	R1-5DP-2C	1.87E-02	2.34E-03	5.10E-04	3.12E-02
SY8610	R2-15DP-1D	6.16E-02	3.92E-03	1.98E-03	6.48E-02
SY8617	R2-5DP-1C	3.41E-02	3.23E-03	2.12E-03	4.30E-02
ST8619	R2-15DP-2A	4.88E-04	2.59E-05	1.38E-07	5.69E-04
From indirectly prepared samples:					
SY8563	R1-5-1B	2.99E-01	5.00E-02	9.52E-03	3.79E-01
SY8578	R1-5-2C	1.04E-01	1.53E-02	1.76E-04	1.66E-01
SY8611	R2-15-1D	1.66E-01	8.92E-02	4.15E-04	2.97E-01
SY8616	R2-5-1C	1.51E-01	3.87E-02	3.69E-04	2.45E-01
	R2-15-2A No indirect analysis available				
RATIOS (b):		16.16	26.74	2.99	11.48
		5.56	6.54	0.35	5.32
		2.69	22.76	0.21	4.58
		4.43	11.98	0.17	5.70
RANGE:		3-16	7-27	0.2-3	4-11

Conclusion: the conversion factor (between indirectly and directly prepared samples) is likely between 2 and 25 for all indices except the B & C Index, based on the range of ratios presented in the lower part of this table for the two PCME indices and the total long structure index.

(a) Filters to be analyzed by asbestos may be prepared either by a direct or an indirect technique (for discussion, see Berman and Chatfield, 1990). However, because the direct technique is traditionally assumed to relate best to available slope factors, measurements derived from indirectly prepared samples need to be converted.

(b) These represent the ratios (quotients) of concentrations derived from the indirectly prepared specimens and the directly prepared specimens of each sample.

TABLE 3
EXPOSURE SCENARIOS AND ATTENDANT RISK ESTIMATES FOR THE DIAMOND XX SITE

				Mean Estimated Asbestos Concentration (s/cc)(a)					Exposure Parameters				
Scenario Number	Exposure Scenario	Appropriate Asbestos Station	Estimated Vehicles per Hour	PCME (EPA 1986)	PCME (Ca: Prop '65)	B & C Index	Total Long Structures	Ind/Dir(b) Conversion Factor	Days per Year	Hours per Day	Years	Fraction Contributed by Scenario	Fraction of Lifetime
1.	Children Bicycling (9 yrs exposure)	25 ft dwnwnd	15	1.40E+00	3.96E-01	3.10E-02	2.44E+00	2 8 25	310	7.3	9	1	0.033
2.	Day Residents in Houses by Road (30 yrs exposure)	150 ft dwnwnd	15	3.04E-01	6.66E-02	7.88E-03	4.89E-01	2 8 25	310	12	30	0.5	0.091
3.	Night Residents in Houses by Road (30 yrs exposure)	150 ft dwnwnd(c)	15	1.54E-01	4.82E-02	5.38E-03	2.79E-01	2 8 25	310	12	30	0.5	0.091
4.	Full Time Residents in Houses (30 yrs exposure)	150 ft dwnwnd	15	Combination of scenarios 2 & 3				2 8 25	310	24(d)	30	1(d)	0.18
5.	Day Residents in Houses by Road (9 yrs exposure)	150 ft dwnwnd	15	3.04E-01	6.66E-02	7.88E-03	4.89E-01	2 8 25	310	12	9	0.5	0.027
6.	Night Residents in Houses by Road (9 yrs exposure)	150 ft dwnwnd(c)	15	1.54E-01	4.82E-02	5.38E-03	2.79E-01	2 8 25	310	12	9	0.5	0.027
7.	Full Time Residents in Houses (9 yrs exposure)	150 ft dwnwnd	15	Combination of scenarios 5 & 6				2 8 25	310	24(d)	9	1(d)	0.054
8.	Continuous Exposure to Background (30 yrs exposure)	Upwind	NV	3.25E-03	8.62E-04	1.03E-05	5.17E-03	2 8 25	310	24	30	1	0.364
9.	Continuous Exposure to Background (9 yrs exposure)	Upwind	NV	3.25E-03	8.62E-04	1.03E-05	5.17E-03	2 8 25	310	24	9	1	0.109

(a) These concentrations are derived from samples prepared by an indirect technique.

(b) This is the conversion factor estimated for converting measurements from indirectly prepared samples to what would be equivalent for directly prepared samples. Note: C(ind)/F = C(dir), where "F" is the conversion factor listed in the table.

(c) These concentration estimates are based on the all night samples collected from the 150 ft downwind station.

(d) For the combination scenarios, the day concentrations are assumed for 12 hours per day and the night concentrations for the remaining 12 hours.

TABLE 3 (Page 2)
ESTIMATED RISKS FOR LUNG CANCER TO SMOKERS AND NON-SMOKERS POTENTIALLY EXPOSED TO DIAMOND XX (a)

		Non-smokers				Smokers			
			PCME				PCME		
		PCME	(Ca: Prop '65)(b)		Long	PCME	(Ca: Prop '65)(b)		Long
Scenario		(EPA 1986)	low	high	Structures	(EPA 1986)	low	high	Structures
Number	Exposure Scenario		estimate	estimate	(B & C Model)		estimate	estimate	(B & C Model)
1.	Children Bicycling	3E-04	1E-04	7E-04	1E-03				
	(9 yrs exposure)	9E-05	2E-05	2E-04	2E-04				
		3E-05	8E-06	6E-05	8E-05				
2.	Day Residents in Houses by Road	2E-04	5E-05	3E-04	5E-04	2E-03	2E-04	2E-03	5E-03
	(30 yrs exposure)	5E-05	1E-05	8E-05	1E-04	6E-04	6E-05	6E-04	1E-03
		2E-05	4E-06	3E-05	4E-05	2E-04	2E-05	2E-04	4E-04
3.	Night Residents in Houses by Road	1E-04	3E-05	2E-04	3E-04	1E-03	2E-04	2E-03	3E-03
	(30 yrs exposure)	3E-05	8E-06	6E-05	8E-05	3E-04	4E-05	4E-04	7E-04
		8E-06	3E-06	2E-05	2E-05	9E-05	1E-05	1E-04	2E-04
4.	Full Time Residents in Houses	3E-04	8E-05	6E-04	8E-04	3E-03	4E-04	4E-03	7E-03
	(30 yrs exposure)	8E-05	2E-05	1E-04	2E-04	8E-04	1E-04	1E-03	2E-03
		3E-05	6E-06	5E-05	7E-05	3E-04	3E-05	3E-04	6E-04
5.	Day Residents in Houses by Road	6E-05	1E-05	1E-04	2E-04	7E-04	7E-05	7E-04	1E-03
	(9 yrs exposure)	2E-05	3E-06	2E-05	4E-05	2E-04	2E-05	2E-04	4E-04
		5E-06	1E-06	8E-06	1E-05	5E-05	6E-06	6E-05	1E-04
6.	Night Residents in Houses by Road	3E-05	1E-05	7E-05	9E-05	3E-04	5E-05	5E-04	8E-04
	(9 yrs exposure)	8E-06	2E-06	2E-05	2E-05	8E-05	1E-05	1E-04	2E-04
		3E-06	8E-07	6E-06	7E-06	3E-05	4E-06	4E-05	6E-05
7.	Full Time Residents in Houses	9E-05	2E-05	2E-04	3E-04	1E-03	1E-04	1E-03	2E-03
	(9 yrs exposure)	2E-05	6E-06	4E-05	6E-05	3E-04	3E-05	3E-04	6E-04
		8E-06	2E-06	1E-05	2E-05	8E-05	1E-05	1E-04	2E-04
8.	Continuous Exposure to Background	9E-06	2E-06	2E-05	2E-05	9E-05	1E-05	1E-04	2E-04
	(30 yrs exposure)	2E-06	6E-07	4E-06	6E-06	2E-05	3E-06	3E-05	5E-05
		7E-07	2E-07	1E-06	2E-06	8E-06	1E-06	1E-05	2E-05
9.	Continuous Exposure to Background	3E-06	7E-07	5E-06	7E-06	3E-05	4E-06	4E-05	6E-05
	(9 yrs exposure)	7E-07	2E-07	1E-06	2E-06	7E-06	9E-07	9E-06	1E-05
		2E-07	6E-08	4E-07	5E-07	2E-06	3E-07	3E-06	5E-06

(a) Unit risk factors used in deriving these risk estimates are provided on Page 5 of the table. Risks are derived by dividing the concentrations estimated for the corresponding scenario (on Page 1 of the table) by the corresponding ind/dir conversion factor (2,8 or 25 listed on Page 1) and multiplying the result by the fraction of lifetime (last column of Page 1) and the appropriate unit risk factor.
Note: read across a row for corresponding values in each scenario.

(b) The State of California provides a range of slope factors for asbestos. The low and high estimates of risk indicated on this table represent the extremes of that range.

TABLE 3 (Page 3)
ESTIMATED RISKS FOR MESOTHELIOMA TO INDIVIDUALS EXPOSED AT DIAMOND XX (a)

Scenario Number	Exposure Scenario	PCME (EPA 1986)	PCME (Ca: Prop '65)(b) low estimate	PCME (Ca: Prop '65)(b) high estimate	Long Structures (B & C Model)
1.	Children Bicycling	3E-03	2E-03	1E-02	1E-03
	(9 yrs exposure)	8E-04	5E-04	3E-03	3E-04
		2E-04	2E-04	8E-04	1E-04
2.	Day Residents in Houses by Road	2E-03	1E-03	5E-03	7E-04
	(30 yrs exposure)	4E-04	2E-04	1E-03	2E-04
		1E-04	8E-05	4E-04	5E-05
3.	Night Residents in Houses by Road	9E-04	7E-04	4E-03	4E-04
	(30 yrs exposure)	2E-04	2E-04	9E-04	1E-04
		7E-05	6E-05	3E-04	3E-05
4.	Full Time Residents in Houses	3E-03	2E-03	8E-03	1E-03
	(30 yrs exposure)	7E-04	4E-04	2E-03	3E-04
		2E-04	1E-04	7E-04	8E-05
5.	Day Residents in Houses by Road	6E-04	3E-04	1E-03	2E-04
	(9 yrs exposure)	1E-04	7E-05	4E-04	5E-05
		4E-05	2E-05	1E-04	2E-05
6.	Night Residents in Houses by Road	3E-04	2E-04	1E-03	1E-04
	(9 yrs exposure)	7E-05	5E-05	3E-04	3E-05
		2E-05	2E-05	8E-05	9E-06
7.	Full Time Residents in Houses	8E-04	6E-04	3E-03	3E-04
	(9 yrs exposure)	2E-04	1E-04	6E-04	8E-05
		7E-05	4E-05	2E-04	3E-05
8.	Continuous Exposure to Background	8E-05	5E-05	3E-04	3E-05
	(30 yrs exposure)	2E-05	1E-05	6E-05	7E-06
		6E-06	4E-06	2E-05	2E-06
9.	Continuous Exposure to Background	2E-05	2E-05	8E-05	8E-06
	(9 yrs exposure)	6E-06	4E-06	2E-05	2E-06
		2E-06	1E-06	6E-06	7E-07

(a) Unit risk factors used in deriving these risk estimates are provided on Page 5 of the table. Risks are derived by dividing the concentrations estimated for the corresponding scenario (on Page 1 of the table) by the corresponding ind/dir conversion factor (2,8 or 25) and multiplying the result by the fraction of lifetime (last column of Page 1) and the appropriate unit risk factor. Note: read across a row for corresponding values in each scenario.

(b) The State of California provides a range of slope factors for asbestos. The low and high estimates of risk indicated on this table represent the extremes of that range.

TABLE 3 (Page 4)

ESTIMATED COMBINED RISKS FOR LUNG CANCER AND MESOTHELIOMA TO SMOKERS AND NON-SMOKERS POTENTIALLY EXPOSED AT DIAMOND XX (a)

		Non-smokers				Smokers			
			PCME				PCME		
		PCME	(Ca: Prop '65)(b)		Long	PCME	(Ca: Prop '65)(b)		Long
Scenario Number	Exposure Scenario	(EPA 1986)	low estimate	high estimate	Structures (B & C Model)	(EPA 1986)	low estimate	high estimate	Structures (B & C Model)
1.	Children Bicycling	3E-03	2E-03	1E-02	2E-03				
	(9 yrs exposure)	8E-04	6E-04	3E-03	6E-04				
		3E-04	2E-04	9E-04	2E-04				
2.	Day Residents in Houses by Road	2E-03	1E-03	5E-03	1E-03	4E-03	1E-03	7E-03	5E-03
	(30 yrs exposure)	5E-04	3E-04	1E-03	3E-04	1E-03	3E-04	2E-03	1E-03
		2E-04	8E-05	4E-04	1E-04	3E-04	1E-04	6E-04	4E-04
3.	Night Residents in Houses by Road	1E-03	7E-04	4E-03	7E-04	2E-03	9E-04	6E-03	3E-03
	(30 yrs exposure)	3E-04	2E-04	9E-04	2E-04	5E-04	2E-04	1E-03	8E-04
		8E-05	6E-05	3E-04	5E-05	2E-04	7E-05	4E-04	2E-04
4.	Full Time Residents in Houses	3E-03	2E-03	9E-03	2E-03	6E-03	2E-03	1E-02	8E-03
	(30 yrs exposure)	8E-04	4E-04	2E-03	5E-04	2E-03	5E-04	3E-03	2E-03
		2E-04	1E-04	7E-04	2E-04	5E-04	2E-04	1E-03	7E-04
5.	Day Residents in Houses by Road	6E-04	3E-04	2E-03	4E-04	1E-03	4E-04	2E-03	2E-03
	(9 yrs exposure)	2E-04	8E-05	4E-04	9E-05	3E-04	9E-05	5E-04	4E-04
		6E-05	2E-05	1E-04	3E-05	1E-04	3E-05	2E-04	1E-04
6.	Night Residents in Houses by Road	3E-04	2E-04	1E-03	2E-04	6E-04	3E-04	2E-03	9E-04
	(9 yrs exposure)	8E-05	6E-05	3E-04	5E-05	2E-04	7E-05	4E-04	2E-04
		2E-05	2E-05	9E-05	2E-05	5E-05	2E-05	1E-04	7E-05
7.	Full Time Residents in Houses	9E-04	5E-04	3E-03	6E-04	2E-03	6E-04	4E-03	3E-03
	(9 yrs exposure)	2E-04	1E-04	7E-04	1E-04	5E-04	2E-04	9E-04	6E-04
		7E-05	4E-05	2E-04	6E-05	1E-04	5E-05	3E-04	2E-04
8.	Continuous Exposure to Background	9E-05	5E-05	3E-04	5E-05	2E-04	6E-05	4E-04	2E-04
	(30 yrs exposure)	2E-05	1E-05	7E-05	1E-05	4E-05	2E-05	9E-05	6E-05
		7E-06	4E-06	2E-05	4E-06	1E-05	5E-06	3E-05	2E-05
9.	Continuous Exposure to Background	3E-05	2E-05	8E-05	2E-05	5E-05	2E-05	1E-04	7E-06
	(9 yrs exposure)	6E-06	4E-06	2E-05	4E-06	1E-05	5E-06	3E-05	2E-05
		2E-06	1E-06	6E-06	1E-06	4E-06	2E-06	9E-06	5E-06

(a) Unit risk factors used in deriving these risk estimates are provided on Page 5 of the table. Risks are derived by dividing the concentrations estimated for the corresponding scenario (on Page 1 of the table) by the corresponding ind/dir conversion factor (2.8 or 25) and multiplying the result by the fraction of lifetime (last column of Page 1) and the appropriate unit risk factor. Note: read across a row for corresponding values in each scenario.

(b) The State of California provides a range of slope factors for asbestos. The low and high estimates of risk indicated on this table represent the extremes of that range.

TABLE 3 (Page 5)

UNIT RISK FACTORS	for lung cancer (s/cc)^-1	for mesothelioma (s/cc)^-1	
for PCME (EPA 1986)	0.16	0.13	for smokers (EPA, 1986)
	0.015	0.13	for non-smokers (EPA, 1986)
for PCME (Ca: Prop '65)	0.8	1.6	high estimate for smokers (California ARB, 1986)
	0.08	0.32	low estimate for smokers (California ARB, 1986)
	0.11	1.6	high estimate for non-smokers (California ARB, 1986)
	0.02	0.32	low estimate for non-smokers (California ARB, 1986)
for long structures	0.21	0.03	for smokers exposed to chryostile (Berman and Crump, 1989)
	0.024	0.03	for non-smokers exposed to chrysotile (Berman and Crump, 1989)

NOTES:

This table is intended as a single, long table; the pages line up so that each row can be read across from Page 1 to Page 4.

Background concentrations employed in determining the risk estimates presented in this table (Scenarios No. 8 & 9) are based on the average of concentrations measured upwind of each road. Concentrations measured at remote background locations were not included in this estimate because a single high value among the remote measurements skews the average of these measurements high. It is likely that this single high measurement is the result of a poor choice of location at which contamination might exist. Interestingly, removing this single high value reduces the estimate of the average concentration for remote background so that it is indistinguishable from the upwind measurements.

The total number of days per year during which exposure may occur for any scenario is estimated as 365 minus 15 days for vacation and 40 days during which precipitation exceeds 0.01 inches. This leaves a net of 310 days.

The number of hours per day during which exposure may occur for any particular scenario is estimated based on the information provided from a survey of individuals living in the Diamond XX area. In some cases it is averaged over varying estimates provided for differing seasons of the year.

The number of years over which exposure is assumed to occur for each scenario is estimated as 9 years for children and either 9 or 30 years for adults, representing an average and conservative case.

The various "discount" factors presented for converting indirect asbestos measurements to direct asbestos measurements are based on the results of the analysis of direct/indirect filter pairs analyzed during this study. Although a clear regression could not be found, the data suggests that the factor lies between 2 and 25 with 8 as a reasonable median estimate. The risk estimates in each row of the table are derived by dividing the indicated concentration (Page 1) by the indicated ind/dir conversion factor (2, 8 or 25) and by multiplying this quotient by the appropriate fraction of lifetime (Page 1) and unit risk factor (listed above).

The estimates of the potency of long asbestos structures come from the 1989 draft hazard assessment document by Berman and Crump. The separate estimates for males and females provided in the document are averaged. The data employed are for exposure to chrysotile specifically. The potency for long structures was extrapolated from the tables to a dust assumed composed of 100% structures longer than 5 um. Separate estimates are provided, respectively, for smokers & non-smokers.

The estimates of the potency of PCME structures (EPA 1986) are derived from the Asbestos Health Effects Assessment Update (EPA, 1986). Potency estimates for males and females are averaged and separate estimates are provided, respectively, for smokers and non-smokers. Potency estimates obtained from the document are derived assuming onset of exposure at the age of 10.

The estimates of potency for PCME structures derived as recommended by California Proposition 65 are derived from California ARB (1986). Independent estimates for males and females are averaged but the separate estimates for smokers and non-smokers are each provided separately. Values from both the low estimates and high estimates provided in the document are presented in the table.

It is assumed that children are non-smokers but that adults may be either smokers or non-smokers.

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APPENDIX A:
DEFINITIONS FOR ASBESTOS EXPOSURE INDICES

DEFINITIONS FOR ASBESTOS CONCENTRATIONS TO BE ANALYZED AT DIAMOND XX

D. Wayne Berman
February 16, 1994

EPA 1986 Definition of PCM Equivalent Asbestos (OHEA):

1. S_i = count all parent structures with length $> 5\ \mu m$ and width $> 0.3\ \mu m$ and components of non-eligible structures with length $> 5\ \mu m$ and width $> 0.3\ \mu m$ (repeat for both i = A and B). Note, all eligible structures must exhibit an aspect (length to width) ratio > 3.

2. Calculate the concentration using the equation for $C_{>5}$ (as defined below).

PCM Equivalent Definition of Asbestos for proposition 65:

1. S_i = count all parent TEM structures (repeat for both i = A and B)

2. Calculate a concentration for short structures, "$C_{<5}$" and a concentration of long structures "$C_{>5}$" in the manner defined below.

3. Sum $C_{<5}$ and $C_{>5}$ and divide the sum by 100.

Berman and Crump Definition of Potent Asbestos:

1. S_i = count all eligible component structures and eligible parent structures that contain no eligible components within the following three size categories:

   - ($5\ \mu m <$ length $< 40\ \mu m$ and width $< 0.3\ \mu m$) (1);
   - ($40\ \mu m <$ length and width $> 5\ \mu m$) (2);
   - ($40\ \mu m <$ length and width $< 0.3\ \mu m$) (3);

   Repeat for both i = A and B and label them $S1_i$, $S2_i$, and $S3_i$, respectively (i.e. six values).

2. Calculate concentrations for each of the three size categories (each using both an Sj_A and an Sj_B, respectively) using the equation defined for $C_{>5}$ below. Label the concentrations C1, C2, and C3, respectively.

3. Determine the following weighted sum:

$$C_{tot} = 0.0017*C1 + 0.0145*C2 + 0.853*C3.$$

EQUATIONS FOR ESTIMATING AIR CONCENTRATIONS

For categories of structures shorter than 5 µm, the equation for estimating concentration from the counts, "S_A" of eligible structures in the proper category is:

$$C_{<5,air} = (10^{-3})*S_A*(V_{disp})*(A_{anal})/[(V_{air})*(f_{ashed})*(V_{filt})*(\#_{g.o.})*(A_{g.o.})]$$

where:

$C_{<5,\,air}$ = the number of eligible structures per cm^3 air (derived as described above);
S_A = the count of eligible structures;
V_{air} = the volume of air filtered (liters);
f_{ashed} = the fraction of the sample filter ashed;
V_{filt} = the volume of the suspension filtered (ml);
$\#_{g.o.}$ = the number of grid openings scanned;
$A_{g.o.}$ = the average area of a grid opening (mm^2);
V_{disp} = the volume of the initial suspension (ml); and
A_{anal} = the effective area of the analytical filter (mm^2).

For structures longer than 5 µm, contributions from both the A and B scans must be summed:

$$C_{>5,\,air} = (10^{-3})*(S_A + S_B)*(V_{disp})*(A_{anal})/[(V_{air})*(f_{ashed})*(Q_A + Q_B)]$$

where:

$Q_i = (V_{filt})_i*(\#_{g.o.})_i*(A_{g.o.})_i$ for scans i = A and B, respectively;
$C_{>5,\,air}$ = the number of eligible structures per cm^3 air (derived as described above);
S_A = the count of eligible structures from scan A;
S_B = the count of eligible structures from scan B;
V_{air} = the volume of air filtered (liters);
f_{ashed} = the fraction of the sample filter ashed;
V_{filt} = the volume of the suspension filtered (ml);
$\#_{g.o.}$ = the number of grid openings scanned;
$A_{g.o.}$ = the average area of a grid opening (mm^2);
V_{disp} = the volume of the initial suspension (ml); and
A_{anal} = the effective area of the analytical filter (mm^2).

EQUATIONS FOR ESTIMATING SOIL CONCENTRATIONS

For categories of structures shorter than 5 µm, the equation for estimating concentration from the counts, "S_A" of eligible structures in the proper category is:

$$C_{<5,soil} = (2)*S_A*(V_{scrb})*(A_{anal})*(M_{est})/[(M_{smpl})*(M_{rel})*(V_{filt})*(\#_{g.o.})*(A_{g.o.})]$$

where:

$C_{<5,\,soil}$ = the number of eligible structures per g soil (derived as described above);
S_A = the count of eligible structures;
M_{est} = the estimated total mass of respirable dust in the sample (g);
M_{smpl} = the measured mass of the initial soil sample (g);
M_{rel} = the measured mass of respirable dust released from the sample (g);
V_{filt} = the volume of the scrubber suspension filtered (ml);
$\#_{g.o.}$ = the number of grid openings scanned;
$A_{g.o.}$ = the average area of a grid opening (mm^2);
V_{scrb} = the volume of the liquid in the scrubber (ml); and
A_{anal} = the effective area of the analytical filter (mm^2).

Note that the factor "2" derives from the fact that only half of the asbestos that is released from the sample is actually captured by the scrubber.

For structures longer than 5 µm, contributions from both the A and B scans must be summed:

$$C_{>5,\,soil} = (2)*(S_A + S_B)*(V_{scrb})*(A_{anal})*(M_{est})/[(M_{smpl})*(M_{rel})*(Q_A + Q_B)]$$

where:

$Q_i = (V_{filt})_i*(\#_{g.o.})_i*(A_{g.o.})_i$ for scans i = A and B, respectively;
$C_{>5,\,soil}$ = the number of eligible structures per g soil (derived as described above);
S_A = the count of eligible structures from scan A;
S_B = the count of eligible structures from scan B;
M_{est} = the estimated total mass of respirable dust in the sample (g);
M_{smpl} = the measured mass of the initial soil sample (g);
M_{rel} = the measured mass of respirable dust released from the sample (g);
V_{filt} = the volume of the scrubber suspension filtered (ml);
$\#_{g.o.}$ = the number of grid openings scanned;
$A_{g.o.}$ = the average area of a grid opening (mm^2);
V_{scrb} = the volume of the liquid in the scrubber (ml); and
A_{anal} = the effective area of the analytical filter (mm^2).

APPENDIX B:
RAW CONCENTRATION DATA AND SAMPLE KEY

TABLE
ESTIMATED CONCENTRATIONS FROM THE DIAMOND XX SITE[1]

			Concentrations (s/cc)			
Sample Number	Sample Type	Prep Tech	PCME (EPA 1986)	PCME (prop '65)	B & C Index	Total Long Structures
SY8556	R1-NV-1A	I	4.00E-03	3.22E-03	8.49E-06	8.66E-03
SY8557	R1-NV-1B	I	3.73E-03	1.03E-03	4.59E-05	7.20E-03
SY8558	R1-NV-1BD	I	2.32E-02	1.45E-02	3.88E-04	5.49E-02
SY8559	R1-NV-1C	I	2.08E-03	2.43E-03	3.07E-05	6.07E-03
SY8560	R1-NV-1D	I	8.87E-03	3.62E-03	2.54E-05	1.94E-02
SY8562	R1-5-1A	I	7.86E-04	2.16E-04	2.36E-05	7.86E-04
SY8563	R1-5-1B	I	2.99E-01	5.00E-02	9.52E-03	3.79E-01
SY8565	R1-5-1C	I	5.78E-03	1.94E-03	1.25E-05	1.21E-02
SY8566	R1-5-1D	I	3.12E-02	1.92E-02	1.10E-04	7.01E-02
SY8567	R1-15-1A	I	1.07E-03	3.93E-04	4.68E-06	3.82E-03
SY8568	R1-15-1BD	I	6.01E-01	2.33E-01	1.70E-03	9.01E-01
SY8569	R1-15-1B	I	7.05E+00	1.55E+00	2.19E-02	1.10E+01
SY8570	R1-15-1C	I	3.98E-01	1.03E-01	3.56E-02	4.67E-01
SY8572	R1-15-1D	I	2.35E-01	4.12E-02	3.25E-04	3.24E-01
SY8574	R1-5-2A	I	7.21E-03	1.35E-03	7.88E-06	9.79E-03
SY8575	R1-5-2B	I	1.93E-01	9.38E-02	4.16E-03	2.96E-01
SY8578	R1-5-2C	I	1.04E-01	1.53E-02	1.76E-04	1.66E-01
SY8579	R1-5-2D	I	5.71E-02	5.07E-02	1.62E-04	1.14E-01
SY8580	R1-15-2A	I	1.92E-03	4.46E-04	1.90E-06	2.56E-03
SY8581	R1-15-2BD	I	2.01E+00	1.30E+00	1.99E-01	4.92E+00
SY8582	R1-15-2B	I	1.10E+00	2.69E-01	2.08E-03	1.47E+00
SY8583	R1-15-2C	I	2.81E-01	6.76E-02	3.98E-04	3.98E-01
SY8584	R1-DB-1	I	2.04E-03	1.58E-04	1.73E-06	3.05E-03
SY8585	R1-15-2D	I	3.99E-02	2.06E-02	7.92E-05	5.99E-02
SY8587	R1-5-3A	I	4.51E-03	1.75E-03	9.07E-06	9.44E-03
SY8589	R1-5-3B	I	1.39E-01	2.27E-02	2.38E-03	2.09E-01
~~SY8590~~	R1-5-3C	I	3.38E-04	4.59E-04	3.74E-06	2.20E-03
SY8591	R1-DB-2	I	2.42E-01	5.69E-02	5.83E-04	3.83E-01
SY8592	R1-5-3D	I	2.50E-02	1.11E-02	1.09E-03	6.25E-02
SY8593	R1-15-3A	I	2.76E-03	5.96E-04	1.56E-06	3.45E-03
SY8594	R1-15-3BD	I	4.68E-01	1.18E-01	1.08E-03	7.36E-01
SY8595	R1-15-3B	I	5.52E-01	1.61E-01	1.53E-03	9.66E-01
SY8596	R1-15-3C	I	7.88E-01	1.27E-01	2.92E-03	1.43E+00
SY8597	R1-15-3CD	I	4.75E-01	5.81E-02	1.14E-03	7.12E-01
SY8598	R1-15-3D	I	7.66E-01	9.14E-02	5.26E-02	1.23E+00
SY8600	R2-NV-1A	I	1.06E-03	7.11E-04	0.00E+00	1.06E-03
SY8601	R2-NV-1B	I	4.03E-03	2.07E-03	1.16E-05	1.05E-02
SY8602	R2-NV-1BD	I	1.47E-02	2.43E-03	2.08E-04	2.94E-02
SY8604	R2-NV-1C	I	3.07E-03	6.94E-04	9.47E-06	6.41E-03
SY8605	R2-NV-1D	I	2.24E-03	2.68E-04	2.13E-04	7.34E-03
SY8606	R2-15-1A	I	6.68E-04	1.04E-04	1.70E-06	1.67E-03
SY8607	R2-15-1B	I	8.69E-01	2.53E-01	9.75E-02	1.16E+00
SY8608	R2-15-1CD	I	1.29E-01	3.24E-02	1.34E-03	2.08E-01
SY8609	R2-15-1C	I	2.46E-01	6.19E-02	4.19E-04	3.85E-01
SY8611	R2-15-1D	I	1.66E-01	8.92E-02	4.15E-04	2.97E-01

TABLE (cont.)

			Concentrations (s/cc)			
Sample Number	Sample Type	Prep Tech	PCME (EPA 1986)	PCME (prop '65)	B & C Index	Total Long Structures
SY8613	R2-5-1A	I	4.89E-04	1.34E-04	5.54E-07	6.52E-04
SY8614	R2-5-1B	I	1.34E-01	7.30E-02	6.84E-04	4.47E-01
SY8616	R2-5-1C	I	1.51E-01	3.87E-02	3.69E-04	2.45E-01
SY8618	R2-5-1D	I	7.83E-02	1.12E-02	1.82E-04	1.61E-01
SY8620	R2-15-2B	I	1.33E+00	1.32E-01	2.47E-03	1.82E+00
SY8621	R2-15-2CD	I	8.10E-01	1.03E-01	1.29E-03	1.24E+00
SY8622	R2-15-2C	I	6.63E-01	1.36E-01	1.29E-03	1.28E+00
SY8623	R2-15-2DD	I	4.56E-01	1.16E-01	8.31E-04	7.49E-01
SY8624	R2-15-2D	I	4.52E-01	1.01E-01	9.08E-04	7.39E-01
SY8626	R2-150DW-AN	I	1.33E-01	4.40E-02	1.04E-02	2.55E-01
SY8627	R2-25DW-AN	I	1.75E-01	5.24E-02	3.58E-04	3.04E-01
SY8628	R2-150UW-AN	I	4.91E-03	2.91E-03	1.34E-05	4.91E-03
SY8629	R2-DB-AN	I	2.48E-03	8.55E-04	7.58E-06	6.44E-03
SY8630	R2-15-3A	I	4.86E-03	1.87E-03	1.24E-05	1.18E-02
SY8631	R2-15-3B	I	3.95E-01	1.60E-01	2.98E-02	1.32E+00
SY8632	R2-15-3CD	I	6.92E-02	4.11E-02	4.75E-03	1.60E-01
SY8633	R2-15-3C	I	1.02E-01	7.91E-02	5.49E-04	3.51E-01
SY8634	R2-15-3D	I	1.10E-02	6.91E-03	2.23E-05	2.14E-02
SY8635	R2-DB-1	I	6.80E-03	2.17E-03	2.48E-05	1.84E-02
SY8636	R2-DB-2	I	6.60E-04	8.31E-04	2.53E-06	2.15E-03
SY8561	R1-FB-1	I	7.57E-04	4.54E-06	0.00E+00	7.57E-04
SY8573	R1-FB-2	I	1.64E-04	8.89E-05	8.38E-07	6.57E-04
SY8586	R1-FB-3	I	3.46E-04	3.46E-06	5.88E-07	6.92E-04
SY8599	R1-FB-4	I	0.00E+00	4.37E-05	0.00E+00	0.00E+00
SY8612	R2-FB-1	I	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SY8625	R2-FB-2	I	1.80E-03	2.37E-04	2.78E-06	3.44E-03
SY8637	R2-FB-3	I	3.30E-04	4.68E-05	2.80E-07	4.95E-04
SY8638	Lab blank	I				
SY8639	Lab blank	I				
SY8640	Lab blank	I				
SY8641	Lab blank	I				
SY8564	R1-5DP-1B	D	1.85E-02	1.87E-03	3.18E-03	3.30E-02
SY8577	R1-5DP-2C	D	1.87E-02	2.34E-03	5.10E-04	3.12E-02
SY8610	R2-15DP-1D	D	6.16E-02	3.92E-03	1.98E-03	6.48E-02
SY8617	R2-5DP-1C	D	3.41E-02	3.23E-03	2.12E-03	4.30E-02
SY8619	R2-15DP-2A	D	4.88E-04	2.59E-05	1.38E-07	5.69E-04

TABLE (cont.)

			Concentrations (s/cc)			
Sample Number	Sample Type	Prep Tech	PCME (EPA 1986)	PCME (prop '65)	B & C Index	Total Long Structures
SY8834	Soil	I	9.54E+07	5.14E+07	2.96E+05	2.02E+08
SY8835	Soil	I	4.08E+07	4.74E+07	1.62E+05	1.12E+08
SY8836	Soil	I	1.35E+07	1.20E+07	4.59E+04	2.53E+07
SY8837	Soil	I	5.65E+07	3.17E+07	1.19E+05	8.98E+07
SY8838	Soil	I	9.87E+07	1.79E+08	1.12E+06	6.58E+08
SY8839	Soil	I	3.87E+07	3.98E+07	8.44E+06	1.58E+08
SY8840	Soil	I	8.84E+06	2.93E+07	1.63E+06	8.49E+07
SY8841	Soil	I	7.51E+07	3.43E+07	3.60E+06	1.82E+08
SY8842	Soil	I	1.54E+08	4.79E+07	3.75E+05	2.54E+08
QC	Soil	I	7.20E+07	6.62E+07	2.75E+05	1.35E+08
QC#4	R1-15-3B	I	7.27E-01	1.49E-01	9.53E-03	1.01E+00
QC#5	R2-15-3B	I	5.26E-01	1.85E-01	2.61E-03	1.90E+00
QC1	R1-NV-18D	I	2.55E-02	1.08E-02	5.79E-05	4.82E-02
QC2	R1-15-18D	I	1.18E+00	2.36E-01	3.35E-03	2.10E+00
QC3	R2-5DP-1C	D	4.27E-02	2.40E-03	5.97E-05	5.52E-02

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[1] All concentrations indices are defined as attached.

DEFINITIONS FOR ASBESTOS CONCENTRATIONS TO BE ANALYZED AT DIAMOND XX

EPA 1986 Definition of PCM Equivalent Asbestos (OHEA):

A count of all parent structures with length > 5 µm and width > 0.3 µm and components of non-eligible structures with length > 5 µm and width > 0.3 µm. Note, all eligible structures must exhibit an aspect (length to width) ratio > 3.

PCM Equivalent Definition of Asbestos for proposition 65:

A count of all parent TEM structures divided by 100. Note, all eligible structures must exhibit an aspect (length to width) ratio > 3.

Berman and Crump Definition of Potent Asbestos:

A weighted sum of three size categories:

- (5 µm < length < 40 µm and width < 0.3 µm) (1);
- (40 µm < length and width > 5 µm) (2); and
- (40 µm < length and width < 0.3 µm) (3).

Call them C_1, C_2, and C_3, respectively.

C_{total} is calculated for this exposure index by the weighted sum:

$$C_{tot} = 0.0017*C1 + 0.0145*C2 + 0.853*C3.$$

Total Long Asbestos Structures

A count of all parent structures with length > 5 µm and aspect (length to width) ratio > 3 and components of non-eligible structures with length > 5 µm and aspect (length to width) ratio > 3.

SAMPLE MANAGEMENT OFFICE

Operated by Viar & Company
a subsidiary of DynCorp
under contract #68-D9-0135
to the U.S. Environmental Protection Agency

FAX COMMUNICATION

Date: 10/14/93

To:

Fax Number:

Name: Kim Lynch

Company: U.S. EPA Region IX

From:

Brad Schorer, Advocate
DynCorp Viar
Regional Operations Section
Direct Dial (703) 519-1439 FAX (703) 683-0378

Subject: EMSCA's problems

Number of Pages, Including This Page: 5

Comments or Special Instructions: Kim, Here is what EMSCA has sent me. They are a list of all of the samples and their condition. Please look at their question about the QC at the bottom of the first page. They are also asking for an extension since they did not receive a response from their call on Oct. 7 about the three samples. Anyway, look these over and I'll call you at 8:30 a.m. PST.

Thanks,
Brad

P.O. Box 818, Alexandria, Virginia 22313, Phone: (703) 684-5678

DATE: October 13, 1993

TO: VIAR & CO., SAMPLE MANAGEMENT OFFICE

ATTENTION: BRAD SCHORER

FAX: 703-683-0378

SUBJECT: SAS 8113-Y-03

EMS Laboratories, Inc., is in receipt of the following samples:

70 Air filters for ISO indirect preparation and analysis
4 Blanks for ISO indirect preparation and analysis
8 Air filters for ISO direct preparation and analysis
9 Soil samples for preparation using a dust generator and
9 of these samples for ISO indirect preparation and analysis

We bid for

75 ISO indirect preparation and analysis
4 Air filters for ISO direct preparation and analysis
7 Soil samples for preparation using a dust generator and
7 of theses samples for ISO indirect preparation and analysis

Enclosed are the list of samples we received and their condition. As mentioned in our conversation of October 6, three of the samples for direct preparation cannot be analyzed by the method. The condition of the filters is as follows:

SY 8751 - Filter was blown
SY 8597 - Uneven loading of particles on the filter
SY 8623 - Very heavy, uneven loading on the filter and not possible to prepare by the direct method

Please tell us how to treat those samples.

Also, should we be using the latest version of the ISO method, or the 1990 Berman-Chatfield procedure.

On the QC, are we to run 5% of the samples as blind duplicates. There was no provision in the bid for QC samples. We inquired about the QC samples in our Letter-FAX of September 23, 1993.

Also, we would like a one week extension since we never received a response to our initial call on October 6.

SAMPLES/METHOD OF ANALYSIS
LN 39006
SAS 8123-Y-93

INDIRECT PREPARATIONS

			CONDITION
SY8638	FILTER BLANK LOT # R3EM49415	9-28-93	Very light
SY8639	FILTER BLANK LOT # R3EM49415	9-28-93	Very light
SY8640	FILTER BLANK LOT # R3JM50685	9-30-93	Very light
SY8641	FILTER BLANK LOT # R3JM50685	9-30-93	Very light

DIRECT PREPARATIONS

	VOLUME	STATION	COLLECTION	CONDITION
SY8564	2070.36	R1-5DP-1B	9-21	Moderate-heavy
SY8571	2200.38	R1-15DP-1C	9-22	Blown filter
(Not suitable for preparation)				
SY8577	2206.80	R1-5DP-2C	9-22	Heavy
SY8597	2229.16	R1-15DP-3C	9-24	Uneven loading
(Not suitable for direct preparation)				
SY8610	2120.97	R2-15DP-1D	9-27	Moderate-heavy
SY8617	2191.3	R2-5DP-1C	9-28	Moderate
SY8619	2293.38	R2-15-2A	9-28	Light-moderate
SY8623	2212.60	R2-15DP-2D	9-28	Very heavy
(Not possible to prepare by direct method)				

INDIRECT PREPARATIONS

	VOLUME	STATION	COLLECTION	CONDITION
SY8556	2178.7	R1-NV-1A.	9-20	Light
SY8557	2333.36	R1-NV-1B	9-20	Light-moderate
SY8558	2223.4	R1-NV-1BD	9-20	Light
SY8559	2280	R1-NV-1C	9-20	Light
SY8560	2294.4	R1-NV-1D	9-20	Light
SY8561	2300.0	R1-FB-1	9-21	Light
SY8562	2285.01	R1-5-1A	9-21	Light
SY8563	2285.14	R1-5-1B	9-21	Moderate
SY8565	2203.96	R1-5-1C	9-21	Light-moderate
SY8566	2194.10	R1-5-1D	9-21	Light-moderate
SY8567	2372.80	R1-15-1A	9-22	Light
SY8568	2180.70	R1-FD-1B	9-22	Very heavy
SY8569	2297.79	R1-15-1B	9-22	Very heavy
SY8570	2364.48	R1-15-1C	9-22	Moderate-heavy
SY8572	2323.70	R1-15-1D	9-22	Moderate-heavy
SY8573	2200.00	R1-FB-2	9-22	Light
SY8574	2202.86	R1-5-2A	9-22	Light
SY8575	2295.24	R1-5-2B	9-22	Light-moderate
SY8576	NO SAMPLE			

8Y8578	2212.20	R1-5-2C	9-22	Light-moderate
8Y8579	2123.94	R1-5-2D	9-22	Light
8Y8580	2250.32	R1-15-2A	9-23	Light
8Y8581	2163.98	R1-FD-2B	9-23	Heavy
8Y8582	2019.96	R1-15-2B	9-23	Heavy
8Y8583	2109.99	R1-15-2C	9-23	Light-moderate
8Y8584	2144.76	R1-DB-1	9-23	Light-moderate
8Y8585	2295.85	R1-15-2D	9-23	Moderate
8Y8586	2100.00	R1-FB-3	9-23	Very light
8Y8587	2217.96	R1-5-3A	9-23	Light
8Y8588	NO SAMPLE			
8Y8589	2222.68	R1-5-3B	9-23	Moderate
8Y8590	2143.60	R1-5-3C	9-23	Light-moderate
8Y8591	2156.48	R1-DB-2	9-22	Light
8Y8592	2278.35	R1-5-3D	9-23	Light-moderate
8Y8593	2185.00	R1-15-3A	9-24	Clean
8Y8594	2211.68	R1-FD-3B	9-24	Moderate-heavy
8Y8595	2216.13	R1-15-3B	9-24	Very heavy
8Y8596	2231.8	R1-15-3C	9-24	Moderate
8Y8598	2275.5	R1-15-3D	9-24	Light-moderate
8Y8599	2196.00	R1-FB-4	9-24	Light
8Y8600	2200.38	R2-NV-1A	9-26	Light
8Y8601	2247.24	R2-NV-1B	9-26	Light
8Y8602	2094.82	R2-NV-1BD	9-26	Light
8Y8603	NO SAMPLE			
8Y8604	2029.47	R2-NV-1C	9-26	Light
8Y8605	2266.88	R2-NV-1D	9-26	Light
8Y8606	2163.98	R2-15-1A	9-27	Light
8Y8607	2153.90	R2-15-1B	9-27	Moderate-heavy
8Y8608	2232.73	R2-FD-1C	9-27	Light-moderate
8Y8609	2219.79	R2-15-1C	9-27	Moderate
8Y8611	2252.73	R2-15-1D	9-27	Moderate
8Y8612	2197.83	R2-FB-1	9-27	Light
8Y8613	2223.5	R2-5-1A	9-28	Light
8Y8614	2230.8	R2-5-1B	9-28	Moderate
8Y8615	NO SAMPLE			
8Y8616	2182.2	R2-5-1C	9-28	Light
8Y8618	2229.8	R2-5-1D	9-28	Light
8Y8620	2332.44	R2-15-2B	9-28	Very heavy
8Y8621	2281.60	R2-FD-2C	9-28	Heavy
8Y8622	2282.90	R2-15-2C	9-28	Moderate-heavy
8Y8624	2325.45	R2-15-2D	9-28	Moderate-heavy
8Y8625	2223.70	R2-FB-2	9-28	Light
8Y8626	5350.18	R2-150DW-AN	9-28	Heavy
8Y8627	5370.30	R2-25DW-AN	9-28	Heavy
8Y8628	5402.23	R2-150UW-AN	9-28	Moderate-heavy
8Y8629	5524.20	R2-DB-AN	9-28	Moderate-heavy

2.

SY8630	2292.62	R2-15-3A	9-29	Light
SY8631	2248.74	R2-15-3B	9-29	Moderate-heavy
SY8632	2316.93	R2-FO-3C	9-29	Light-moderate
SY8633	2281.40	R2-15-3C	9-29	Light-moderate
SY8634	2321.28	R2-15-3D	9-29	Light
SY8635	2280.54	R2-DB-1	9-29	Light-moderate
SY8636	2196.60	R2-DB-2	9-29	Light
SY8637	2176.20	R2-FB-3	9-29	Light

Bulk samples for dust generator sample preparation and ISO indirect sample preparation and analysis:

SY8834
SY8835
SY8836
SY8837
SY8838
SY8839
SY8840
SY8841
SY8842

APPENDIX C:
DATA VALIDATION REPORT

ICF KAISER
ENVIRONMENT & ENERGY GROUP

ICF Kaiser Engineers, Inc.
160 Spear Street, Suite 1380
San Francisco, CA 94105-1535
415/882-3000 Fax 415/882-3199

MEMORANDUM

TO: Dan Shane
On Scene Coordinator
Emergency Response Section, H-8-3

THROUGH: Richard Bauer
Environmental Scientist
Quality Assurance Management Section (QAMS), P-3-2

FROM: Margie D. Weiner MDW
Senior Data Review Oversight Chemist
Environmental Services Assistance Team (ESAT)

DATE: March 15, 1994

SUBJECT: Review of Analytical Data

Attached are comments resulting from ESAT Region 9 review of the following analytical data:

SITE: Diamond XX
EPA SSI NO.: N3
CERCLIS I.D. NO.: Not Applicable
CASE/SAS NO.: SAS 8113Y-03 Memo #02
SDG NO.: 1, 2, 3, 5, and 6

LABORATORY: EMS Laboratories, Inc. (EMSCA)
ANALYSIS: SAS Asbestos

SAMPLE NO.: 86 Air Samples (See Case Summary)

COLLECTION DATE: September 22 through 30, 1993

REVIEWER: Dina D. David, ESAT/ICF Kaiser

The comments presented in this report have been reviewed and approved by the EPA Task Monitor for the ESAT Contract, whose signature appears above.

If there are any questions, please contact Margie D. Weiner (ESAT/ICF) at (415) 882-3061, or Richard Bauer (QAMS/EPA) at (415) 744-1499.

Attachment

cc: Kira Pyatt Lynch, QAMS, P-3-2
D. Wayne Berman, ICF Kaiser - Oakland

ICF KAISER

Data Validation Report

Case No.: SAS 8113Y-03 Memo #02
Site: Diamond XX
Laboratory: EMS Laboratories, Inc. (EMSCA)
Reviewer: Dina D. David, ESAT/ICF Kaiser
Date: March 15, 1994

I. Case Summary

SAMPLE INFORMATION: SAMPLE #:

SDG-1: SY8556 through SY8564, SY8566, SY8567, SY8569, SY8577, SY8610, SY8617, SY8619, and SY8638 through SY8641

SDG-2: SY8565, SY8568, SY8570, SY8572 through SY8575, SY8578, SY8579, SY8581, SY8582, SY8583, SY8585, SY8589, SY8590, SY8591, SY8594, SY8598, SY8602, and SY8609

SDG-3: SY8568-QC, SY8584, SY8587, SY8592, SY8593, SY8595, SY8596, SY8597, SY8601, SY8604, SY8607, SY8608, SY8611, SY8614, SY8616, SY8618, SY8620, SY8624, SY8626, and SY8627

SDG-5: SY8595-QC, SY8631-QC, SY8580, SY8599, SY8600, SY8605, SY8606, SY8612, SY8613, SY8621, SY8622, SY8623, and SY8628 through SY8635

SDG-6: SY8558-QC, SY8617-QC, SY8586, SY8625, SY8636, and SY8637

COLLECTION DATE: September 20 through 30, 1993
SAMPLE RECEIPT DATE: October 5, 1993

MATRIX: 86 Air Samples

FIELD QC: Field Blanks (FB): SY8561, SY8573, SY8586, SY8599, SY8612, SY8625, and SY8637
Filter Blanks: SY8638, SY8639, SY8640, and SY8641
Background Samples: SY8584, SY8591, SY8636, SY8637, and SY8629
Duplicates (D1): SY8558 and SY8558 (Duplicate)
(D2): SY8568 and SY8569
(D3): SY8581 and SY8582
(D4): SY8594 and SY8595
(D5): SY8601 and SY8602
(D6): SY8608 and SY8609
(D7): SY8621 and SY8622
(D8): SY8632 and SY8633

LABORATORY QC: Duplicates: SY8568, SY8595, SY8631, SY8558, and SY8617

ANALYSIS: Asbestos

Analyte	Sample Preparation Date	Analysis Date
Asbestos	October 6 through December 11, 1993	October 22 through December 21, 1993

GENERAL COMMENTS:

Samples SY8564, SY8571, SY8577, SY8597, SY8610, SY8617, SY8619, and SY8623 were submitted to the laboratory for direct preparation and analysis. The laboratory noted in the case narrative that sample SY8571 had a blown filter, and samples SY8597 and SY8623 had very heavy and uneven loadings. The laboratory contacted the Region for resolutions for the above deficiencies. The Region informed the laboratory to cancel the analysis of sample SY8571 and to prepare samples SY8597 and SY8623 using an indirect preparation technique.

The "A" and "B" designation on each sample refer to the analysis for all size fibers and for ≥5 μm length fibers, respectively.

All of the samples were analyzed according to method ISO/CD 13794 as stated in the case narrative submitted by the laboratory for all of the sample delivery groups (SDGs). However, the proposed validation procedures submitted by D. Wayne Berman noted that the method employed for analysis of the asbestos samples is ISO/TC 146/SC 3/WG1 N39: Ambient Air: Determination of asbestos fibers by an indirect-transfer transmission electron microscopy procedure.

Corrections made in the data packages, including the use of liquid correction fluid, were not appropriately documented by the laboratory.

There were no data confirming the measurements and calculations of the average grid opening size for each lot of grid specimens used in the analysis of the samples in any of the SDGs. In addition, no diffraction pattern data were included in any of the SDGs.

This report was prepared in accordance with the "Proposed Validation Procedures For Diamond XX," Revised February 18, 1994 by D. Wayne Berman.

II. Validation Summary

A. Calibrations:

Camera Constant

- Precision of the estimates for the camera constant are within the acceptable range of ±1 for all of the SDGs.
- All indicated multiplications are correct. Note that for camera constant (3*) on page 753, the laboratory reported a value of 303.5 instead of 30.35. However, the laboratory used the correct value (30.35) in the calculation for the camera constant average.
- All of the camera constants were correctly transcribed to the corresponding data summary sheets.

Magnification

- Precision of the estimates for the 19300X and 25000X magnifications are within the acceptable range of ± 2% for all of the SDGs.

  For ≥5 μm size range, the laboratory used 9200X/9300X as the screen magnification in the analysis of all of the samples in all of the SDGs. However, the calibration data at the above screen magnification was not provided by the laboratory.

- All of the appropriate magnifications were correctly transcribed to the corresponding data summary sheets.

Grid Opening Size

- There were no data confirming the measurements and calculations of the average grid opening size for each lot of grid specimens used in the analysis of the samples in all of the SDGs.

B. Discrepancies/transcription errors noted in the validation of the data for all of the SDGs:

SDG-1

1. On the data summary sheet for sample SY8557B (pg. 15), the structure type and identification for structure #26 on grid opening B1/D3-2 were switched.

2. On the data summary sheet for sample SY8558A (pgs. 19-20), the width for structure #49 on grid opening C1/E3-2 was calculated and reported as 0.05 μm instead of 0.10 μm. After structure #49, the size dimensions are offset by 1 place. The dimensions for structure #49 are entered for structure #50, the dimensions for structure #51/MD10 are entered for structure #51/MF, and so on. The error in offset continued all the way to structure #69. The raw data for structure #69 on page 224 was not used in the calculation.

3. On the data summary sheet for sample SY8561A (pg. 36), the laboratory used 9200X instead of 19400X and 19200X in the calculations for the size dimensions reported for structure #1 on grid opening B1/F3-3 and for structure #2 on grid opening C1/C2-3.

4. On the data summary sheet for sample SY8563A (pg. 50), the identification for structure #53 on grid oppening B1/E3-2 was incorrectly reported as CD instead of CM.

5. On the data summary sheet for sample SY8564B (pg. 57), the length for structure #57 on grid opening B1/C3-2 was incorrectly reported as 1.52 μm instead of 15.22 μm.

6. On the data summary sheet for sample SY8566B (pg. 64), the width for structure #62/CD on grid opening C1/F4-4 was incorrectly reported as 11.96 μm instead of 10.87 μm. In addition (pg. 62), the structure type for structure #7 on grid opening A1/G2-4 was incorrectly reported as CF instead of CM.

7. On the data summary sheet for sample SY8569A (pg. 72), the level of analysis reported for chrysotile and amphibole was ISO for both, instead of CM-CDQ and ADQ, respectively. In addition, the total number of grid openings was not reported.

8. On the data summary sheet for sample SY8610A (pg. 85), dimensions for structure #74 on grid opening B1/D3-1 were incorrectly calculated and reported.

9. On the data summary sheet for sample SY8617A (pg. 90), the length for structure #51 on grid opening B1/D3-4 was incorrectly reported as 8.33 μm instead of 5.21 μm.

10. On the data summary sheet (pg. 110), sample SY8640A was reported as SY8640.

11. The type of microscope used was not checked/marked on the worksheet for the following samples:

Sample number	Page(s)
SY8557A	188
SY8559A	247

12. On the worksheet for sample SY8556B (pg. 138), screen magnification was listed as 19400X instead of 9300X.

13. Analysis information for screen magnification and camera constant for sample SY8559A was not provided on the worksheet (page 253). In addition (pgs. 285-286), screen magnification of 9200X was used in the calculation for structures #44-50 instead of 9300X.

14. In the calculation of the dimensions for structures #56-64 on grid openings C1/C2-3 and C1/C2-4 for sample SY8557A, a screen magnification of 19400X was used, instead of 19300X as reported on the worksheet (pg. 188).

15. On the worksheets for sample SY8556B (pgs. 149-153 and 156-159), sample SY8558B (pgs. 227 and 238), sample SY8559B (pgs. 267-272), sample SY8560B (pgs. 305-306), sample SY8562B (pgs. 371-375), sample SY8563B (pgs. 416 and 428), sample SY8564B (pg. 449), sample SY8566B (pg. 487), sample SY8610B (pg. 629), and sample SY8617B (pg. 663), the screen magnification was listed as 9000X instead of 9200X.

16. The EDS analyses for the following samples were not numerically labelled in the comment section of the worksheet:

Sample Number	Page(s)
SY8556A	120, 131
SY8556B	136-138, 157-158, 164, 167
SY8559A	240
SY8559B	255-258
SY8562A	363
SY8562B	380-382
SY8564A	430-432
SY8577A	563-564, 577
SY8577B	585, 594
SY8610A	599-600
SY8610B	622, 633
SY8617A	639-643
SY8617B	667, 673
SY8619A	676, 684
SY8619B	688-690, 699-700, 712-713, 719

SDG-2

1. No Inventory Sheet was provided for this SDG.

2. On the data summary sheet for sample SY8570B (pg. 19), the dimensions for structure types CD/MB and CD/MF for structure #61 on grid opening C1/C5-2 were switched.

3. On the data summary sheet (pg. 27), sample SY8573B was entered as SY573B. For structure #7 on grid opening D1/F4-4, no calculated dimensions were entered on the data summary sheet.

4. On the data summary sheet for sample SY8579A (pgs. 43-44), the dimensions for structures #24-42 on grid opening B1/D4-2 were incorrectly calculated and reported.

5. On the data summary sheet for sample SY8579B (pg. 45), the width for structure #22 on grid opening B1/G4-2 was incorrectly reported as 3.23 μm instead of 3.76 μm.

6. On the data summary sheet for sample SY8582B (pg. 57), the grid opening for structures #22-24 should be B1/E3-2 as listed on the worksheet (pg. 456) instead of B1/E3-3.

7. On the data summary sheets (pgs. 51 and 59), samples SY8581A and SY8583A were reported as SY8581 and SY8583, respectively.

8. On the data summary sheet for sample SY8590B (pg. 76), the length for structure #24 on grid opening D1/G5-3 was incorrectly reported as 6.45 μm instead of 7.10 μm.

9. On the data summary sheet for sample SY8594A (pg. 84), the structure type and identification for structure #42 on grid opening C1/D2-4 were switched.

10. On the data summary sheet for sample SY8609B (pg. 101), the identification and structure type for structure #40 on grid opening C1/D4-4 were switched.

11. On the worksheets for samples SY8565B and SY8575B (pgs. 135-138 and 334), screen magnification was listed as 9000X instead of 9200X. On the worksheet for sample SY8579B (pgs. 378 and 403), screen magnification was listed as 9300 instead of 19300.

12. On the worksheet for sample SY8568A (pg. 146), type of microscope used was not marked/checked.

13. For sample SY8598B, no elemental analysis was performed for structure #11/CDQ on grid opening A1/C2-4.

14. The EDS analyses for the following samples were not numerically labelled in the comment section of the worksheet:

Sample Number	Page(s)
SY8574B	310-311
SY8579B	391
SY8582A	434
SY8582B	448
SY8589A	522
SY8589B	537
SY8590A	551
SY8590B	566
SY8598B	673

15. The level of analysis transcribed on the data summary sheets was CM-CDQ (for chrysotile) instead of CD-CDQ as listed on the worksheets for the following samples: SY8565, SY8570, SY8572, SY8573, SY8575, SY8579, SY8582, SY8585, SY8590, SY8594, and SY8602.

SDG-3

1. On the data summary sheet for sample SY8584B (pg. 13), the width for structure #23 on grid opening F1/C4-1 was incorrectly reported as 8.15 μm instead of 8.47 μm.

2. On the data summary sheet for sample SY8587A (pg. 15), the length for structure #9 on grid opening A1/E2-2 was incorrectly reported as 0.05 μm instead of 0.57 μm.

3. On the data summary sheet for sample SY8587B (pg. 19), the width for structure #50 on grid opening C1/B3-4 was incorrectly reported as 1.72 μm instead of 17.20 μm.

4. On the data summary sheet for sample SY8593B (pg. 26), grid opening A1/F4-2 was not reported. In addition (pg. 27), the length for structure #14 on grid opening A1/B3-4 was incorrectly reported as 8.60 μm instead of 9.14 μm.

5. On the data summary sheet for sample SY8596A (pg. 35), the width for structure #16 on grid opening B1/C4-4 was incorrectly reported as 3.37 μm instead of 3.41 μm.

6. On the data summary sheet for sample SY8597A (pg. 41), the width for structure #59 on grid opening B1/D2-4 was incorrectly reported as 1.24 μm instead of 1.76 μm.

7. On the data summary sheet for sample SY8604B (pg. 52), the width for structure #1 on grid opening A1/D2-2 were incorrectly reported as 0.22 μm and 4.35 μm instead of 2.39 μm and 0.43 μm, respectively.

8. On the data summary sheet for sample SY8611A (pg. 66), the width for structure #68 on grid opening B1/D3-3 was incorrectly reported as 0.16 μm instead of 1.55 μm.

9. On the data summary sheet for sample SY8611B (pg. 69), the width for structure #25 on grid opening A1/E3-2 was incorrectly reported as 0.54 μm instead of 5.91 μm.

10. On the data summary sheet for sample SY8618A (pg. 78), the total number of grid openings was reported as 8 instead of 9. In addition (pg. 79), the width for structure #37 on grid opening C1/C4-1 was reported as 5.73 μm instead of 5.99 μm, and the structure type for structure #57 on grid opening C1/D3-1 was incorrectly reported as MF instead of F.

11. On the data summary sheet for sample SY8626B (pg. 94), the dimensions for structures #26-28 on grid opening B1/D3-2 were incorrectly reported as 0.32 μm & 0.00 μm, 10.75 μm & 0.32 μm, and 77.42 μm & 0.11 μm, instead of 10.75 μm & 0.32 μm, 77.42 μm & 0.11 μm, and 8.06 μm & 0.32 μm, respectively.

12. On the data summary sheet for sample SY8627A (pg. 96), the length for structure #21/CD-MF on grid opening B1/F3-3 was reported as 0.10 μm instead of 1.15 μm.

13. Analysis information listed on page 467 differs from the initial information listed on page 466 for sample SY8608A. Type of instrument used, screen magnification, and camera constant changed even though the same grid opening was being observed.

14. On the worksheet for sample SY8614A (pgs. 536-537), the structure numbers were incorrectly numbered. The structure numbers should have been #42-56 instead of #34-48. Note that the data summary sheet for the above sample listed the correct structure numbers.

15. The EDS analyses for the following samples were not numerically labelled in the comment section of the worksheet:

Sample Number	Page(s)
SY8568-QC	99
SY8584A	128
SY8584B	138
SY8587A	170
SY8587B	185-186
SY8592A	204,205
SY8592B	221
SY8595A	270
SY8595B	293
SY8596B	321
SY8601A	363
SY8607A	437-438
SY8608A	466
SY8608B	482
SY8614A	524
SY8618A	581-582
SY8618B	596
SY8620B	625
SY8627B	714

SDG-5

1. On the data summary sheet for sample SY8605B (pg. 30), the dimensions for structure #52 on grid opening C1/D5-4 were incorrectly reported as 6.99 μm and 4.30 μm instead of 7.07 μm and 4.34 μm, respectively.

2. On the data summary sheet for sample SY8613B (pg. 48), the grid opening was incorrectly reported as B1/C4-4 instead of B1/B4-4 for structure #8.

3. On the data summary sheet for sample SY8628A (pg. 64), the length for structure #14 on grid opening A1/D5-2 was incorrectly reported as 13.28 μm instead of 8.07 μm.

4. On the data summary sheet for sample SY8630B (pg. 74), structure #11 on grid opening A1/F3-1 was not reported.

5. On the data summary sheet (pg. 81), sample SY8632A was reported as SY8632. In addition, all of the dimensions for structures #1-14 on grid opening A1/D3-3 were incorrectly calculated and reported.

6. On the data summary sheet for sample SY8633A (pg. 87), a screen magnification of 19300X was used instead of 19200X in the calculation of the dimensions for structures #25-52 on grid openings B1/D2-4 through F3-1 and C1/E4-4 through G4-2.

7. On the data summary sheet for sample SY8633B (pgs. 88-89), a screen magnification of 9300X was used instead of 9200X in the calculation of the dimensions for structures #18-36 on grid openings B1/D4-4 through G3-2.

8. On the worksheet for samples SY8580A (pg. 108), no results for the EDS analyses were reported for structure #12 on grid opening A1/F5-4.

9. On the worksheet for sample SY8580B (pg. 125), no results for the EDS analyses were reported for structure #11 on grid opening A1/E6-1.

10. On the worksheet (pg. 269), sample SY8606B was reported as sample SY8602.

11. On the worksheet for sample SY8630B (pg. 527), screen magnification was listed as 19300X instead of 9300X.

12. The EDS analyses for the following samples were not numerically labelled in the comment section of the worksheet:

Sample Number	Page(s)
SY8580A	107-108
SY8580B	122-127
SY8595-QC	700
SY8606B	286-289
SY8613B	341, 358
SY8621A	369-370
SY8623A	426-427
SY8630B	530-531
SY8631A	545
SY8632B	590

SDG-6

1. On the data summary sheet for sample SY8636A (pg. 25), the structure number for the second structure CM/F on grid opening A1/F2-1 was not reported. The structure number should have been #13.

2. On the data summary sheet for sample SY8636B (pg. 27), the grid opening was incorrectly reported as A1/F4-1 instead of A1/D4-1 for structure #3.

3. The EDS analyses for the following samples were not numerically labelled in the comment section of the worksheet:

Sample Number	Page(s)
SY8617-QC	67
SY8636A	171
SY8636B	184-186

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ENVIRONMENT & ENERGY GROUP

ICF Kaiser Engineers, Inc.
160 Spear Street, Suite 1380
San Francisco, CA 94105-1535
415/882-3000 Fax 415/882-3199

MEMORANDUM

TO: Dan Shane
On Scene Coordinator
Emergency Response Section, H-8-3

THROUGH: Richard Bauer
Environmental Scientist
Quality Assurance Management Section (QAMS), P-3-2

FROM: Margie D. Weiner
Senior Data Review Oversight Chemist
Environmental Services Assistance Team (ESAT)

DATE: March 7, 1994

SUBJECT: Review of Analytical Data

Attached are comments resulting from ESAT Region 9 review of the following analytical data:

SITE:	Diamond XX
EPA SSI NO.:	N3
CERCLIS I.D. NO.:	Not Applicable
CASE/SAS NO.:	SAS 8113Y-03 Memo #01
SDG NO.:	4
LABORATORY:	EMS Laboratories, Inc. (EMSCA)
ANALYSIS:	SAS Asbestos
SAMPLE NO.:	9 Soil Samples (See Case Summary)
COLLECTION DATE:	September 24 and 25, 1993
REVIEWER:	Karen Pettit, ESAT/ICF KAISER

The comments presented in this report have been reviewed and approved by the EPA Task Monitor for the ESAT Contract, whose signature appears above.

If there are any questions, please contact Margie D. Weiner (ESAT/ICF) at (415) 882-3061, or Richard Bauer (QAMS/EPA) at (415) 744-1499.

Attachment

cc: Kira Pyatt Lynch, QAMS, P-3-2
D. Wayne Berman, ICF Kaiser-Oakland

ICF KAISER

Data Validation Report

Case No.: SAS 8113Y-03 Memo #01
Site: Diamond XX
Laboratory: EMS Laboratories, Inc. (EMSCA)
Reviewer: Karen Pettit, ESAT/ICF KAISER
Date: March 7, 1994

I. Case Summary

SAMPLE INFORMATION: SAMPLE #: SY8834 through SY8842

COLLECTION DATE: September 24 and 25, 1993
SAMPLE RECEIPT DATE: October 5, 1993

MATRIX: 9 Soil Samples

FIELD QC: Field Blanks (FB): None
Equipment Blanks (EB): None
Background Samples (BG): None
Duplicates (D1): SY8841 and SY8842

LABORATORY QC: Duplicates : SY8842

ANALYSIS: Asbestos

Dust Generation Date: October 25 through November 9, 1993
Slide Preparation Date: December 2, 1993 through December 8, 1993
Analysis Date: December 3 through 9, 1993

GENERAL COMMENTS:

The "A" and "B" designation on each sample refer to the analysis for all size fibers and for ≥5 μm length fibers, respectively.

This report was prepared in accordance with "Proposed Validation Procedures For Diamond XX" submitted by D. Wayne Berman on February 18, 1994.

II. Validation Summary

A. Calibrations:

Camera Constant

- The precision for the camera constant estimates all fell within the acceptable range of ±1.
- The multiplications were all checked and found to be correct.
- All of the camera constants were correctly transcribed except for an entry on page 142, where the camera constant for the

instrument used should have been 30.4 instead of 28.2, as entered.

Magnifications

- There were calibrations performed for magnifications at 19300X and 25000X. The precision for these magnification estimates is within the acceptable range of ±2%.

  In addition to the analyses performed at magnifications of 19300/19200X, there were analyses performed at 9200/9300X that have no calibration data.

- All of the appropriate magnifications were correctly transcribed from the analysis sheet to the data report summary sheets.

Grid Opening Size

- There was no data confirming the measurements and calculations of the average grid opening size for the lot of grid specimens used in the analysis of the samples for this SDG.

B. Discrepancies/transcription errors noted in the validation of the data for this SDG:

1. The calculations for the net weight of the actual mass of total respirable dust were checked for each sample and were correct except for the following calculation discrepancies in the sample data.

Sample Number	Raw Data	Data Entry	Reported on Table 1	Recalculated for Table 1
SY8836	1.2662	1.2870	1.2870	1.2704
SY8837	1.2228	1.2228	1.2228	1.4228

The raw data was reviewed for completeness and to ensure that the results were correctly calculated. The raw data masses entered here are correct. The data entry sheet amounts and the amounts reported on Table 1 (Summary of Air Elutriator Results) were checked against the raw data amounts. The Table 1 data recalculations for the actual total mass of respirable dust released are the sums of the three columns containing masses released at various RPMs for each sample.

For sample SY8836, both the amounts reported on the data entry sheets and the amounts reported on Table 1 disagree with the raw data amounts. The recalculated total amount for Table 1 disagrees with both the total reported on Table 1 and the raw data total.

When the total respirable mass was recalculated on Table 1 for sample SY8837, it did not agree with the amount reported.

2. When the raw data was checked against the data entry sheets several transcription errors were found on the data entry sheets. The number of grid openings were miscounted, the entry on the data summary sheet was 42 instead of 43 as counted on the analysis sheet for sample SY8835B. The structure numbers for sample SY8840B on the data summary sheet, from number 18 to number 52, disagree with the numbers on the analysis sheets for the same sample.

   The width of structure #6 in sample SY8837B was entered as 0.76 μm. It should have been 7.61 μm.

3. Table 1 was resubmitted on February 18, 1994 with different entries for the estimated total mass of respirable dust and different entries for the percent of dust in the sample. The data entry sheets were not changed, so all of the data sheets for samples SY8834 through SY8842 do not agree with Table 1.

4. An EDS elemental analysis was performed for all parent structures bearing a "Q" designation on the analysis sheets. Although the data was correctly transcribed, samples SY8836A (page 97-98), SY8842A (page 266), and SY8842B (page 281) were not labelled in the analysis sheet comment section.

5. Both high and low magnification scans were performed for all samples and the scans at lower magnification reported only structures greater than or equal to 5 μm.

6. Some of the raw analysis sheets were incomplete.

   a. The instrument identification was omitted from ten of the analysis sheets for the following samples.

Sample Number	Grid Address	Page Number
SY8836B	1C	124
SY8839B	1C	208
SY8840B	1C	233
SY8841A	1C	249
SY8841B	1C	263
SY8842A	1C	277
EMS Blank-B	1C	324
QC Blank-A	1B	330
QC Blank-A	1C	351
QC Blank-B	1C	359

   b. There were seven analysis sheets for QC Blanks with inadequate sample identification. Since the blanks were prepared on several different dates, there should be a distinction between QC blanks. The analysis sheets are pages 330, 333, 339, 343, 351, and 359.

APPENDIX D:
ANOVA RESULTS

ANALYSIS OF ASBESTOS CONCENTRATIONS MEASURED DURING THE SEPTEMBER, 1993 EPA STUDY CONDUCTED AT DIAMOND XX

This analysis consisted of three major tasks:

1) comparison of direct and indirect measurements of asbestos concentrations;
2) analysis to determine important factors affecting asbestos and PM10 concentrations; and
3) analysis of the relationship between respirable dust (PM10) concentrations and asbestos concentrations.

These analyses were conducted separately for three methods of calculating asbestos concentration: *PCME (EPA 1986)*, EPA's method for calculating PCM equivalent concentrations (EPA 1986); *PCME (Ca: Prop '65)*, a California Proposition 65 method for calculating PCM equivalent concentrations (California ARB 1986); and *the B & C Index*, a method proposed by Berman and Crump (1994). The three asbestos concentrations so calculated were labeled C_1, C_2, and C_3, respectively.

THE DATA SET

The data that were available were obtained from samplers that were set up at defined distances up and downwind from two roadways located within the Diamond XX residential area in California. A more detailed discussion of the experimental design under which the asbestos and PM10 samples were collected is provided in the Experimental Design Section of the main text of this report.

Briefly, asbestos and PM10 concentrations were measured under controlled conditions at both roadways at four sampler locations (stations) close to each roadway (1 station 150 feet upwind and 3 downwind stations that were 25, 75, and 150 feet from the road). One station was also set up at a location distant from each roadway to collect measurements representative of remote background.

During the study, a control vehicle traversed the road at a constant speed of 30 mph and at three different frequencies (representing the number of passes per hour): 0, 5, and 15 vehicles per hour (vph). The concentrations measured at the distant background stations were not considered to be associated with any particular vehicle frequency. A graphic representation of the experimental design is presented in Figure D-1.

A total of 65 sample filters were prepared by the indirect technique and analyzed to derive estimated airborne asbestos concentrations at specific sampling stations during specific runs. These include 12 pairs of duplicate samples (with paired filters collected immediately adjacent to the each other). Four filters representing laboratory blanks and seven filters representing field blanks were also prepared and analyzed. Five additional sample filters (each paired with one of the other sample filters described above) were also collected, prepared by a direct technique, and analyzed.

ANALYSIS OF DATA

Comparison Between Measurements Derived from Directly and Indirectly Prepared Samples

Of the five measurements derived from samples prepared by a direct technique, only four could be paired with a duplicate measurement derived from an indirectly prepared sample. The sample to be prepared indirectly from the fifth pair was lost.

Each of the remaining 4 measurements from directly paired samples was paired with the corresponding measurement from the indirectly prepared sample. A linear regression analysis was then conducted among these four pairs of measurements with the exposure concentrations expressed as each of three exposure indices defined as described in the first section above:

- PCME (EPA 1986);
- PCME (Ca Prop '65); and
- the B & C index.

The results of the linear regression were then examined to determine the relationship between direct and indirect concentrations.

The results of the regression analysis suggest that there is little or no relationship between measurements derived, respectively, from directly and indirectly prepared samples for the four sets of observations available from this study; measurements on indirectly prepared samples do not appear to be significantly related to measurements derived from directly prepared samples. None of the slopes of the best fit lines (for each of the three exposure indices) are significantly different from zero. Even when the log-transformed concentrations were regressed on one another, no significant relationships were detected.

Important factors affecting asbestos concentrations

An analysis of variance was conducted to examine the effects of roadway, proximity to the road, vehicle frequency, and day-to-day variations on the concentrations of asbestos that were observed. Given the design of the experiment (see Figure D-1) the following terms were included in the model:

Roadway (R);

Gross Proximity (a parameter to distinguish remote background measurements from measurements collected at other stations: NF);

R and NF interaction (R*NF);

Station, within R and NF (S(R*NF));

Vehicle Frequency, within R and NF (V(R*NF));

S and V interaction (S*V(R*NF));

Day, within R, NF, S and V (D(R*NF*S*V));

Sample Number, within D, R, NF, S, and V (SN(R*NF*S*V*D)); and

Test Number, within SN, D, R, NF, S, and V (TN(R*NF*S*V*D*SN)).

The variable *NF* was introduced because the remote background samples could not be associated with a particular vehicle frequency. It was not appropriate to classify the remote background samples according to vehicle frequency, so the NF variable differentiates the remote background from the other stations. Sample number, *SN*, is a variable that differentiates field duplicates, when such duplicates exist, from their collocated samples. Test number, *TN*, was used to identify the laboratory QC samples that were available for four filters. The variation of TN, within SN and the other variables, can be associated with error introduced by laboratory handling and analysis of filters. Having the QC samples allows estimation of that component of the overall variance. The variation associated with SN includes the variation introduced within the laboratory, but it also includes other, unidentified factors contributing to differences in collocated samples. The variation associated with SN is a measure of pure error with respect to the model; it represents variation in the results that is not accounted for by other terms of the model (such as roadway, station, etc.).

Preliminary applications of the model specified above, ignoring the Day, SN, and TN terms, were applied to all three sets of asbestos concentrations, where the concentrations were expressed either on the natural scale or on the log-scale (i.e., with and without log-transformation). The residuals from those model fits were examined and tested for normality, to determine if the data expressed in either scale satisfy the normality assumptions of analysis of variance. For the log-scale data, but not for the natural-scale data, the residuals appeared to be satisfactorily described by a normal distribution (based on the Shapiro-Wilk test). Thus, application of the full model and inferences about the significance of the terms of the model were based on applications to the log-transformed data.

The results of the analysis of variance using the full model are summarized in Table D-1. Note that, by design, all the degrees of freedom were accounted for in the model, i.e., there was no error term. For each case, the appropriate term to use as a measure of error depends on the effect being tested.

The significance of SN was assessed by comparing the mean square associated with SN to that associated with TN, i.e., we wished to determine if the variation associated with SN, which includes the TN component, was significantly greater than that associated with TN alone. For the C_1 and C_2 exposure indices, the sample-to-sample variation is significantly greater than the test-to-test variation alone (p-value on the SN line of Table D-1 less than 0.01) whereas for C_3 there does not appear to be significantly more variation from collocated samples than that introduced by laboratory handling.

The significance of day-to-day variation, within station, vehicle number and roadway, was assessed in comparison to the variation associated with SN, within day, station, vehicle number and roadway. As seen in Table D-1, the variation from day to day (the mean square for D(NF*R*S*V)) was little or no greater than that for SN, for all three exposure indices, and the p-values reflect that lack of significance. From this we concluded that the variation from day-to-day could be considered a component of the error term, so that the mean squares for D(NF*R*S*V), which include day-to-day, sample-to-sample within day, and test-to-test within sample contributions, can be used as the error term for the remaining tests of significance.

For all three asbestos exposure indices, the following results were revealed. Statistical significance, or lack thereof, for all of the comparisons is clear-cut, the tests of the effects are either highly significant ($p < 0.01$) or not significant ($p > 0.10$) with no border-line cases. Results indicate that:

- differences between the measurements at remote background and the other stations (considered as a whole) are statistically significant;
- differences between measurements collected at the two roadways are not significant; the two roadways did not appear to differ with respect to overall rate of asbestos release. The interaction between roadway and NF is also insignificant;
- the effects of station location within roadway and NF do differ significantly from one another; this implies that variation between the stations in close proximity to the roadways (A, B, C, and D, as opposed to the remote background station) is significant; and
- the effect of vehicle frequency is also highly significant. The interaction between station and vehicle frequency is not significant for the exposure indices, C_1 and C_3, but is significant for C_2. Thus, for C_2 but not for C_1 or C_3, the additive effect of vehicle frequency on ln(C) over and above the effect due to station depends on which station is being considered.

To compare the various stations or vehicle frequencies to one another, we reduced the model in accordance with the above results. Roadway was no longer considered in the model. Moreover, the distant background samples were associated with a dummy station identifier ("E") and a dummy vehicle frequency ("-1") so that NF could also be dropped from the model. The resulting model had the terms S, V, S*V, D(S*V), SN(S*V*D), and TN(S*V*D*SN). As before, the SN and TN terms identify specific components of the error contributed by unidentified differences in collocated samples and laboratory handling, respectively, whereas the day term, D(S*V), includes those components as well as day-to-day variation. The D(S*V) term is the appropriate error term for assessing the differences between station and vehicle frequency. The degrees of freedom in the full model associated with roadway, NF, and the nesting of the other terms within roadway and NF now contribute to the mean square for D(S*V), which has 36 degrees of freedom for the reduced model.[1]

When the reduced model was run, the station and vehicle frequency effects remain highly significant. The interaction between station and vehicle frequency appear to be significant, at least at the 0.05 level, for all three asbestos exposure indices. Figure D-2 summarizes the station and vehicle frequency comparisons, obtained using a least significant difference (LSD) approach for multiple comparisons.

Stations A (upwind) and E (remote background) exhibit consistently the lowest asbestos concentrations. Somewhat surprisingly, the concentration at station A is significantly less than that for station E when concentrations are measured using the two exposure indices C_1 and C_2. The downwind stations always exhibit significantly greater concentrations than stations A or E and it appears that there is a trend of decreasing asbestos concentration with downwind distance from the road. The station closest to the road (B) shows significantly greater asbestos concentrations (using the C_2 and C_3 exposure indices) than do stations C and D and significantly greater concentrations (using the C_3 exposure index) than does station D; stations C and D do not differ significantly with respect to any asbestos concentration.

When no vehicles were run over the roads (0 vehicles per hour), the asbestos concentrations are indistinguishable from remote background concentrations. In all cases, a frequency of 15 vehicles per hour is associated with significantly greater asbestos concentrations than the other frequencies. A frequency of 5 vehicles per hour is intermediate. When concentrations are expressed using the C_1 index, runs at 5 vph yield no significantly greater concentrations than the remote background concentrations, although they do yield significantly greater concentrations than 0 vph. Using the C_2 exposure index, concentrations associated with runs at 5 vph are significantly different from those associated with runs at 0 vph and from concentrations measured at remote background locations. Using the C_3 exposure index, asbestos concentrations during runs at 5 vph are essentially the same as concentrations measured in association with 0 vph but are significantly greater than concentrations measured at remote background locations.

When mean concentrations for the distinct combinations of station and vehicle frequency are listed (Figure D-2), the patterns confirm the analyses of station and vehicle frequency alone. The highest concentrations are found in association with 15 vph at downwind stations and also for 5 vph at the closest station (B). The next highest concentrations were observed further downwind, stations C and D, during runs of 5 vehicles per hour. The lowest concentrations were observed when no vehicles were using the roadway, for remote background, and for the upwind station.

Because the downwind stations are located at specified distances from the road, an analysis of variance that considered vehicle frequency as a categorical variable and distance as a continuous variable was used to explain variations in $\ln(C_i)$ at stations B, C, and D. That analysis had effects due to vehicle frequency, a common slope factor for relating asbestos concentration to distance, and separate slope factors for the different vehicle frequencies. The significance of the separate slope factors was tested and found to be not significant. However, the common slope is

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[1] Because of a missing $\ln(C_3)$ value due to one C_3 value of 0, D(S*V) has only 35 degrees of freedom for C_3.

significantly different from zero and the intercept terms do apparently differ from one vehicle frequency to another. Consequently, a model with separate intercepts but a common slope was fit to the $\ln(C_i)$ data. That model was found to significantly describe the results; the model accounts for 67%, 70%, and 47% of the variation in $\ln(C_1)$, $\ln(C_2)$, and $\ln(C_3)$, respectively. A weighted average of the vehicle frequency-specific slope factors yields an estimate of the common slope with the smallest variance (Hyde, 1980). The results of the estimation, converted back to the natural scale, are as follows:

C_1 = exp(-4.55 - 0.012*distance) for 0 vph;
C_1 = exp(-2.28 - 0.012*distance) for 5 vph;
C_1 = exp(0.153 - 0.012*distance) for 15 vph;

C_2 = exp(-5.38 - 0.011*distance) for 0 vph;
C_2 = exp(-3.57 - 0.011*distance) for 5 vph;
C_2 = exp(-1.20 - 0.011*distance) for 15 vph;

C_3 = exp(-9.72 - 0.016*distance) for 0 vph;
C_3 = exp(-6.74 - 0.016*distance) for 5 vph;
C_3 = exp(-4.57 - 0.016*distance) for 15 vph.

Factors affecting PM10 concentrations

The 42 PM10 concentrations were subjected to analysis of variance techniques in the same manner as described above for asbestos concentrations. In the case of PM10, however, the observations were limited to stations A, B, C, and D (i.e., remote background measurements were not collected) and two vehicle frequencies (5 and 15 vph). The reduced data base allowed a slight streamlining of the modeling (see Table D-2).

Unlike the asbestos data, there were no QC samples for PM10 to allow estimation of the laboratory handling component of error variance. There were only three collocated samples from which to estimate the component of error variance associated with the unidentified differences between collocated samplers.

The results of the analysis of variance are shown in Table 2. In the case of PM10, the day-to-day variation is significantly greater than the variation associated with collocated samples. The roadway, station, and vehicle frequency effects are significant contributors to differences in PM10 concentrations. The D(R*S*V) term was used as the error term for assessing the effects of roadway, station, and vehicle frequency. A comparison of the means for those effects is also included in Table D-2.

Relationship between PM10 and asbestos concentrations

The 42 PM10 concentrations were matched with their corresponding indirect asbestos concentrations (three asbestos concentrations for each PM10 concentration, because of the three methods of calculating asbestos concentration). The analytical approach employed is a variation of an analysis of variance known as a homogeneity of slopes model.

The approach adopted included effects due to roadway and station, and their interaction, a common slope factor for relating asbestos concentration to PM10 concentrations, and separate slope factors for the different roadway/station combinations. The significance of the separate slope factors can be tested for significance; if there is no significant difference among the slope factors, then a weighted average of the roadway/station-specific slope factors yields an estimate of the common slope with the smallest variance (Hyde, 1980).

Because of the results cited above indicating that log-transformed concentrations are better described by normal distributions than the untransformed data, the PM10 analyses were performed using log-transformed concentrations. The error term is contributed by day-to-day variation, consistent with the determination from the previous analysis that such variation is an appropriate measure of error, which includes sample-to-sample and test-to-test contributions.

For the regressions relating PM10 to each of the three exposure indices by which asbestos concentrations were reported, the roadway effect is not significant but the station effect is significant (Table D-3). Moreover, it appears that the slopes for the relationship between $\ln(C_i)$ and ln(PM10) do not differ from one station to another but that the common slope is significantly different from zero. The model with a single slope factor, but differing intercepts depending on station, describes the data very well (the significance of the model exceeds 0.0001) and accounts for a large proportion of the variation in $\ln(C_i)$ values (75% for $\ln(C_1)$, 79% for $\ln(C_2)$, and 71% for $\ln(C_3)$).

Since roadway is not significant, the estimation of the common slope, β, was been based on station alone (pooling the observations from the two roadways within station). The least squares estimator of β is given by the weighted average of the station-specific slopes:

$$\beta = \Sigma b_i * SSX_i \,/\, \Sigma SSX_i,$$

where b_i is the estimated slope at station i and SSX_i is the corrected sum of squares for ln(PM10) at that station. This weighted average was computed for the three asbestos concentrations to yield these equations:

$$\begin{aligned} \ln(C_1) &= \alpha_j + 1.392*\ln(PM10), \\ \ln(C_2) &= \alpha_j + 1.077*\ln(PM10), \\ \ln(C_3) &= \alpha_j + 1.422*\ln(PM10), \end{aligned}$$

where j = A, B, C, or D. Transforming back from the log-scale and specifying values of the α_j's, the relationships between asbestos concentrations and PM10 concentrations are:

$$\begin{aligned} C_{1A} &= 22.2*(PM10)^{1.392}, \\ C_{1B} &= 1.65*(PM10)^{1.392}, \\ C_{1C} &= 1.38*(PM10)^{1.392}, \\ C_{1D} &= .393*(PM10)^{1.392}, \end{aligned}$$

$$\begin{aligned} C_{2A} &= 18.3*(PM10)^{1.077}, \\ C_{2B} &= .387*(PM10)^{1.077}, \\ C_{2C} &= .188*(PM10)^{1.077}, \\ C_{2D} &= .094*(PM10)^{1.077}, \end{aligned}$$

$$C_{3A} = .0029*(PM10)^{1.422},$$
$$C_{3B} = .0056*(PM10)^{1.422},$$
$$C_{3C} = .0091*(PM10)^{1.422},$$
$$C_{3D} = .0101*(PM10)^{1.422}.$$

The results shown above suggest that the relationship between PM10 and asbestos concentrations is not linear. Moreover, the relationships are not similar for the three methods of calculating asbestos concentrations. Although the power on PM10 concentration does not differ greatly from method to method, the coefficients differ, especially for the third method (Berman and Crump). The concentration of asbestos relative to PM10 concentration clearly depends on distance from the roadway (cf. the significant p-values for station in Table 3; the station terms are significant also in the models that ignored roadway). For the exposure indices C_1 and C_2, there is more asbestos for a fixed concentration of PM10 at station A, upwind from the road, than at the downwind stations. Moreover, the concentration of asbestos for a fixed PM10 concentration decreases with distance downwind. For the exposure index C_3, on the other hand, less asbestos is present per PM10 concentration upwind from the road and asbestos concentration per PM10 Aconcentration increases, although only slightly, as distance downwind increased.

FIGURES

FIGURE D-1
GRAPHIC DEPICTION OF DIAMOND XX ASBESTOS CONCENTRATION EXPERIMENT

	ROADWAY 1					ROADWAY 2				
STATION(a)	A	B	C	D	E	A	B	C	D	E
DAY 1	0(b)	0	0	0						
2	5	5	5	5						
3	5/15	5/15	5/15	5/15						
4	5/15	5/15	5/15	5/15	X					
5	15	15	15	15						
6						0	0	0	0	
7						15	15	15	15	
8						5	5/15	5/15	5/15	
9						15	15	15	15	X

(a) Stations A are 150 feet upwind from roadways, B - 25 feet downwind, C - 75 feet downwind, D - 150 feet downwind, and E - distant background.

(b) An entry (0, 5, or 15) indicates vehicle frequency for samples collected that day. Note that on days 3, 4, and 8 two experiments were conducted. For Station E, samples were collected on days 4 and 9; the X's indicate that those samples are not associated with any particular vehicle frequency.

FIGURE D-2

COMPARISON OF ASBESTOS MEASUREMENTS ASSOCIATED WITH SPECIFIC COMBINATIONS OF STATION AND VEHICLE FREQUENCY FROM THE DIAMOND XX STUDY

Exposure Index (a)

C1	Station (s):	B	C	D	E	A
	Mean(a):	-1.4	-2.6	-2.8	-5.0	-6.3
	Vehicle Frequency (V):		15	5	-1	0
	Mean:		-1.7	-3.9	-5.0	-5.3

S * V:	B15	C15	B5	D15	D5	C5	BO	E	DO	CO	AO	A5	A15
Mean:	-0.06	-1.2	-1.7	-1.8	-3.1	-4.3	-4.6	-5.0	-5.4	-6.0	-6.2	-6.3	-6.3

C2	Station (s):	B	C	D	E	A
	Mean:	-2.7	-3.8	-3.9	-6.2	-7.4
	Vehicle Frequency (V):		15	5	0	-1
	Mean:		-3.0	-5.0	-6.2	-6.2

S * V:	B15	C15	B5	D15	D5	C5	BO	E	AO	CO	DO	A5	A15
Mean:	-1.4	-2.6	-2.9	-3.0	-4.0	-5.3	-5.6	-6.2	-6.5	-6.6	-6.9	-7.6	-7.7

C3	Station (s):	B	C	D	E	A
	Mean:	-6.2	-7.9	-8.1	-11.1	-12.3
	Vehicle Frequency (V):		15	5	0	-1
	Mean:		-7.1	-9.1	-10.0	-11.1

S * V:	B15	B5	C15	D15	D5	C5	BO	DO	C5	CO	E	AO	A5	A15
Mean:	-5.0	-5.9	-6.4	-7.6	-8.3	-9.5	-9.5	-9.5	-10.1	-11.0	-11.0	-11.7	-12.1	-12.7

(a) The exposure indices examined in this study are:

C1 = PCME (EPA, 1986)
C2 = PCME (California Prop. 65)
C3 = B and C Index (Berman and Crump, 1994)

Note that underlines indicate cases in which differences in groups are not significant. For example, the difference in the mean concentrations measured for Station B (using index C1) is significantly greater than the mean for Station D. However, the mean concentrations measured at Station C (using exposure index C1) is NOT significantly different than the mean for Station D.

TABLES

TABLE D-1
ANALYSIS OF VARIANCE FOR LOG TRANSFORMED ASBESTOS CONCENTRATIONS GROUPED BY SPECIFIED PARAMETERS

	DEGREES OF		Mean Square			F-Test p-Value	
EFFECT (a)	REEDOM	C1(b)	C2(b)	C3(b)	C1(b)	C2(b)	C3(b)
NF	1	16.2	16.9	32.8	< 0.01	< 0.01	< 0.01
R	1	0.69	0.66	0.03	> 0.10	> 0.10	> 0.10
NF * R	1	4.89	0.38	1.94	> 0.10	> 0.10	> 0.10
S(NF * R)	6	30.0	29.0	43.6	< 0.01	< 0.01	< 0.01
V(NF * R)	4	28.3	22.7	24.5	< 0.01	< 0.01	< 0.01
S * V(NF * R)	12(c)	3.37	3.89	5.77	> 0.10	< 0.01	> 0.10
D(NF * R * S * V)	23	1.91	1.14	3.10	> 0.10	> 0.10	> 0.10
SN(NF * R * S * V * D)	12	1.75	2.2	3.57	< 0.01	< 0.01	> 0.10
TN(NF * R * S * V * D * SN)	4	0.08	0.01	1.67			
Converted Total	64(c)						

(a) Key:
NF = Gross Proximity
R = Roadway
S = Station
V = Vehicle
D = Day
SN = Station Number
TN = Test Number

(b) The exposure indices examined in this study are:
C1 = PCME (EPA, 1986)
C2 = PCME (California Prop. 65)
C3 = B and C Index (Berman and Crump, 1994)

(c) Due to a C3 concentration value of 0 (from Roadway 2, Station A, 0 vehicles per hour, collected 9/26/93), only 64 log-transformed C3 values were available for analysis. Thus, for C3, the degree of freedom for corrected total and S * V(NF * R) sums of squares are 1 less than shown, i.e., 63 and 11, respectively.

TABLE D-2
ANALYSIS OF VARIANCE FOR LOG-TRANSFORMED PM10 CONCENTRATIONS MEASURED DURING THE DIAMOND XX STUDY

EFFECT	DEGREES OF FREEDOM	MEAN SQUARE	F-TEST p-VALUE
R	1	1.04	0.05
S	3	10.8	< 0.01
v	1	2.89	< 0.01
R * S	3	0.24	> 0.10
R * V	1	0.04	> 0.10
S * V	3	0.33	> 0.10
R * S * V	3	0.16	> 0.10
D(R * S * V)	23	0.24	< 0.01
SN(R * S * V * D)	3	0.007	

Comparison of Means:

Roadway:	1	2		
Mean:	-1.5	-1.8		
Station:	B	C	D	A
Mean:	-0.7	-1.3	-1.7	-3.2
Vehicle Frequency:	15	5		
Mean:	-1.4	-2.0		

Note: means connected by underlines are not significantly different from one another.

TABLE D-3

ANALYSIS OF VARIANCE FOR RELATIONSHIPS BETWEEN ln (PM10) and ln (Ci) MEASURED DURING THE DIAMOND XX STUDY

EFFECT	DEGREES OF REEDOM	Mean Square			F-Test p-Value		
		C1(a)	C2(a)	C3(a)	C1(a)	C2(a)	C3(a)
Roadway	1	0.17	0.12	0.32	0.75	0.74	0.75
Station	3	60	62	95	< 0.01	< 0.01	< 0.01
Roadway * Station	3	2.0	2.3	2.0	0.31	0.12	0.58
PM10 (Common Slope)	1	31	19	25	< 0.01	< 0.01	< 0.01
PM10 * Roadway * Station (separate slope)	7	1.8	20	5.8	0.39	0.11	0.11
Error	26	1.6	1.1	3.0			
Collected Total	41						

(a) The exposure indices examined in this study are:

C1 = PCME (EPA, 1986)

C2 = PCME (California Prop. 65)

C3 = B and C Index (Berman and Crump, 1994)

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Appendix E-5

Sacramento Bee Report

San Joaquin Environmental Inc.

Environmental Health,
Industrial Hygiene, and
Occupational Safety
Services

7257 N. Maple Avenue, Ste. 108, Fresno, CA 93720 • Tel: (209) 298-8500 • Fax (209) 298-3500

February 2, 1998

[illegible] OCT 26 AM 9:35

Chris Bowman
Environmental Writer
Sacramento Bee
2100 Q Street
Sacramento, Ca 95816

Dear Mr. Bowman:

TREMOLITE-FERROACTINOLITE
(SOLID SOLUTION SERIES) CONTAMINATION
EL DORADO HILLS-SHINGLE SPRINGS FINAL REPORT

Further to your letter of September 4, 1997, which contained a signed Contract of Retention, a site visitation was made to the Shingle Springs, El Dorado Hills area on Saturday September 6, 1997. The purpose of the site visitation was to undertake sampling for tremolite contamination of residences and the surrounding environment. It is my understanding that tremolite contamination was believed to be in the Shingle Springs area originating from geological deposits of tremolite which were being disturbed during road construction and development of land zoned for residential use.

Background

Tremolite and actinolite are both naturally occurring amphibole minerals. They are chemically very similar and differ primarily in that actinolite has a greater Fe^2 (iron) content. (See Figure 1). Chemically, they are referred to as occurring in a "Solid-Solution Series" in that it is difficult to differentiate where tremolite and actinolite end and begin, respectively. Analysis of what is believed to be tremolite utilizing Transmission Electron Microscopy (TEM), Selected Area Electron Diffraction (SAED), and energy dispersive X-ray analysis (EDX) will often reveal the mineral to be actinolite and not tremolite. Both amphibole minerals occur in metamorphic formations in both contact and regionally metamorphosed rocks. These conditions occur throughout the Sierra Nevada foothill range and, as a result, veins of asbestos are common. By-far the majority of the asbestos found in California is Chrysotile, which is a serpentine mineral that has been extracted commercially. Tremolite frequently occurs as an impurity of chrysotile, however, large deposits of tremolite-actinolite are, geologically speaking, rare.

Sampling Methodology

During the site visitation made to the Shingle Springs area of El Dorado County on September 6, 1997, the residence of Terry Trent was visited. During a tour of the property owned by Mr. Trent, veins of tremolite and surface contamination of tremolite was evident. On the unpaved road leading to Mr. Trent's and a neighbor's residences, tremolite was seen to have been washed onto the road (Cothrin Ranch Road) from exposed roadside veins.

Air sampling for asbestos was conducted outside the residence of Terry Trent, on the northern and southern edges of the property, and inside the residence (family room). In addition, air sampling was conducted at the side of the unpaved Cothrin Ranch Road leading to Mr. Trent's home and a neighbor. During the sampling at the side of the road, six passes were made by a motor vehicle. In addition, air sampling for asbestos was conducted outside the residence of Judy Bolander, at 3329 Woedee Drive. Sampling and subsequent analysis were conducted following the Yamate Level II Method.

Two settled dust samples each were taken from each of the following locations: inside the residence of Judy Bolander (3329 Woedee Drive); the residence of Terry Trent (3893 Wild Turkey Drive); and in the residence of Sue Beck (3540 Cothrin Ranch Road). Sampling was conducted following ASTM Method D5755-95[1], analysis for asbestos was conducted following ASTM Standard Test Method D22.07.P008.

A sample of road dust was collected from the unpaved road leading to the residence of Terry Trent (Cothrin Ranch Road). Sampling and analysis were conducted following EPA Method 600/4-83-043.

A sample of potable well water was collected from the residence of Terry Trent and analyzed for asbestos content following EPA Method 600/4-83-043.

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[1] ASTM Method D5755-95 Standard Test Method for Microvacuum Sampling and indirect analysis of dust by Transmission Electron Microscopy for Asbestos structure number concentration (1995)

Results

Table 1 (attached) summarizes the results of analysis of the six microvac dust samples collected from the three residences in the Shingle Springs, El Dorado Hills area.

The two dust samples collected from 3320 Woedee Drive contained 60,300 and 22,110 asbestos structures per square centimeter (s/cm^2). These samples were collected from the living room shelf and above the front door trim (inside), respectively. The asbestos structures were identified mineralogically as chrysotile and tremolite-ferroactinolite forms.

The two dust samples collected from 3540 Cothrin Ranch Road contained 464,408 and 4,145 s/cm^2. These samples were collected from on top of an exposed ceiling beam and on top of the front door trim, respectively. The dust sample collected from the ceiling beam contained chrysotile and tremolite-ferroactinolite forms of asbestos, as well as non-asbestos ferroactinolite. The sample collected above the front door contained only the tremolite-ferroactinolite form of asbestos.

The two dust samples collected from 3893 Wild Turkey Drive contained 8,955 and 11,058 s/cm^2. These samples were collected from on top of a computer in the office and from a dining room shelf, respectively. The asbestos structures were identified mineralogically as chrysotile and tremolite-ferroactinolite forms. The computer dust sample also contained some non-asbestos forms of ferroactinolite.

Table 2 (attached) summarizes the results of analysis of a single potable water sample collected from the kitchen forcet in Mr. Trent's house, 3893 Wild Turkey Drive. Analysis revealed no asbestos detected.

Table 3 (attached) summarizes the results of analysis of a single road dust sample collected from Cothrin Ranch Road. Analysis revealed the sample to contain 0.0046% asbestos by weight. The asbestos structures were identified mineralogically as chrysotile and tremolite-ferroactinolite forms.

Table 4 (attached) summarizes the results of analysis of five air samples for the presence of asbestos. The three air samples collected from 3893 Wild Turkey Drive were found to have asbestos concentrations at or below the limit of detection/analytical sensitivity. The air sample collected from outside the residence located at 3329 Woedee Drive was found to contain 0.0042 asbestos structures per cubic centimeter (s/cm^3), equivalent to 24 structures per millimeter squared (s/mm^2). The asbestos structures detected were all found to be chrysotile.

The air sample collected from the side of Cothrin Ranch Road was found to contain 0.2204 s/cm^3, equivalent to 81 asbestos s/mm^2. The asbestos structures detected were all found to be tremolite/actinolite.

Discussion

During the site visit made to the Shingle Springs area on September 6, 1997 outcrops of tremolite-actinolite veins were evident at most road cuttings and areas being developed for homes. On Cothrin Ranch Road tremolite-actinolite was present in mineral veins at the side of the road and had washed onto the unpaved road itself. Air monitoring revealed high levels of tremolite-actinolite fibers being released into the air when a sport utility vehicle was driven past the test site on six occasions during a period of 47 minutes.

The Beck residents, located at 3540 Cothrin Ranch Road, reported that they had experienced rock and mud erosion of road cuttings right above their home, which had washed material down to their front door. The Bolander residents, at 3329 Woedee Drive, had veins of tremolite-actinolite in their front yard left exposed after the area was developed for residential use. Close to Woedee Drive, tremolite-actinolite veins were exposed in other road cuts of this new subdivision, which is next to Oak Ridge High School.

From the limited air and water sampling conducted, levels of asbestos in air and drinking water were generally low in the Shingle Springs area, with the exception of Cothrin Ranch Road, where vehicular traffic on a tremolite-actinolite contaminated unpaved road created conditions for the release of asbestos fibers to the ambient air.

The level of asbestos in dust collected from three residences, all built after 1978, were variable. Levels of asbestos (total of all kinds) in settled dust as determined by the microvac technique are considered low if less than 1000 s/cm^2. Levels above 10,000 s/cm^2 are considered generally above background. Levels above 100,000 s/cm^2 are considered high and indicative of a source of contamination.[1] All three of the residences tested had at least one sample above

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[1] Millette J.R. and Hays S.M. (1994) Settled Asbestos Dust Sampling and Analysis. Published by Lewis Publishers.

10,000 s/cm^2. The Beck residence, located at 3540 Cothrin Ranch Road, which had experienced mud slides from a road cutting the previous year, had a level of 464,408 s/cm^2 on top of a 4"x8" high ceiling beam.

Elevated levels of tremolite-actinolite within the three residences are most likely due to the naturally occurring tremolite-actinolite mineralization in the area which is being uncovered and released during road construction, commercial and residential development. Exposed tremolite-actinolite in road cuttings is eroding onto sidewalks and roads, increasing the potential of the mineral being broken down further into small enough fragments to become airborne and potentially respirable. The presence of elevated levels of asbestos on high surfaces inside the three residences suggests that the asbestos must have been airborne at some stage.

Currently, there are no federal or state standards for the maximum permissible level of asbestos in ambient air or settled house dust. There are standards for the presence of asbestos in the air of school buildings (kindergarten through 12th grade), as well as standards for the occupational environment. However, these standards cannot be used for comparison with the data from these samples since the residences are not places of employment or school buildings.

Epidemiological studies conducted over the past fifty years have shown that the risks of exposure to the major commercial asbestos fiber types encountered in mining, milling, manufacturing, and product use are increases in lung cancer, the development of mesothelioma asbestosis and pleural plaques. There is an increasing consensus that amphibole exposure (crocidolite, amosite, and tremolite-actinolite) is more hazardous than exposure to chrysotile, particularly as it relates to mesothelioma risk. In addition, there has been some debate as to whether the mesothelioma risk is attributable to chrysotile or to its common contaminant, tremolite. Epidemiological information concerning tremolite as a potential health risk comes from studies of workers occupationally exposed as a consequence of tremolite contamination of minerals, such as chrysolite, vermiculite and talc. In addition, there have been some epidemiological studies of residents of Anatolia, Turkey and Metsovo, Greece where exposures from naturally occurring deposits of tremolite have resulted in pleural thickening and calcifications, malignant pleural mesothelioma, and diffuse interstitial fibrosis. The preponderance of epidemiological evidence indicates that tremolite asbestos exposures result in respiratory health consequences similar to other forms of asbestos exposure, including lung cancer and mesothelioma.

My limited visual observation of the El Dorado Hills - Shingle Springs area, as well as the limited testing undertaken, does not support the notion that naturally occurring tremolite in the region has been substantially disturbed so as to create an imminent health hazard. Moreover, there is no evidence at this stage to suggest that the El Dorado Hills - Shingle Springs residents have a significantly greater risk of developing respiratory ailments observed in similar tremolite mineralized areas of Turkey and Greece. However, it would seem prudent from a public health perspective to minimize the disturbance of the tremolite mineralization in the area during residential and commercial development as well as minimize the potential for release of tremolite to the air where tremolite is exposed, until the health risks have been evaluated in a more rigorous scientific manner.

Since the tremolite mineralization has been disturbed and there is clear, albeit limited, evidence that residences are showing signs of tremolite accumulation in house dust, a thorough investigation should be undertaken to determine the full extent of tremolite contamination in the area and what long term impact, if any, the tremolite mineralization may have on the health of the residents.

Should you have any questions or if we can be of further assistance, please do not hesitate to contact us.

Sincerely,

Christopher J. Tennant, PhD, CIH, REA
Certified Industrial Hygienist

Professor, Environmental Health/Industrial Hygiene
California State University, Fresno

THE AMERICAN BOARD OF INDUSTRIAL HYGIENE
CERT. NO 6055
EXPIRES 12-31-2000
CHRISTOPHER J. TENNANT, CIH

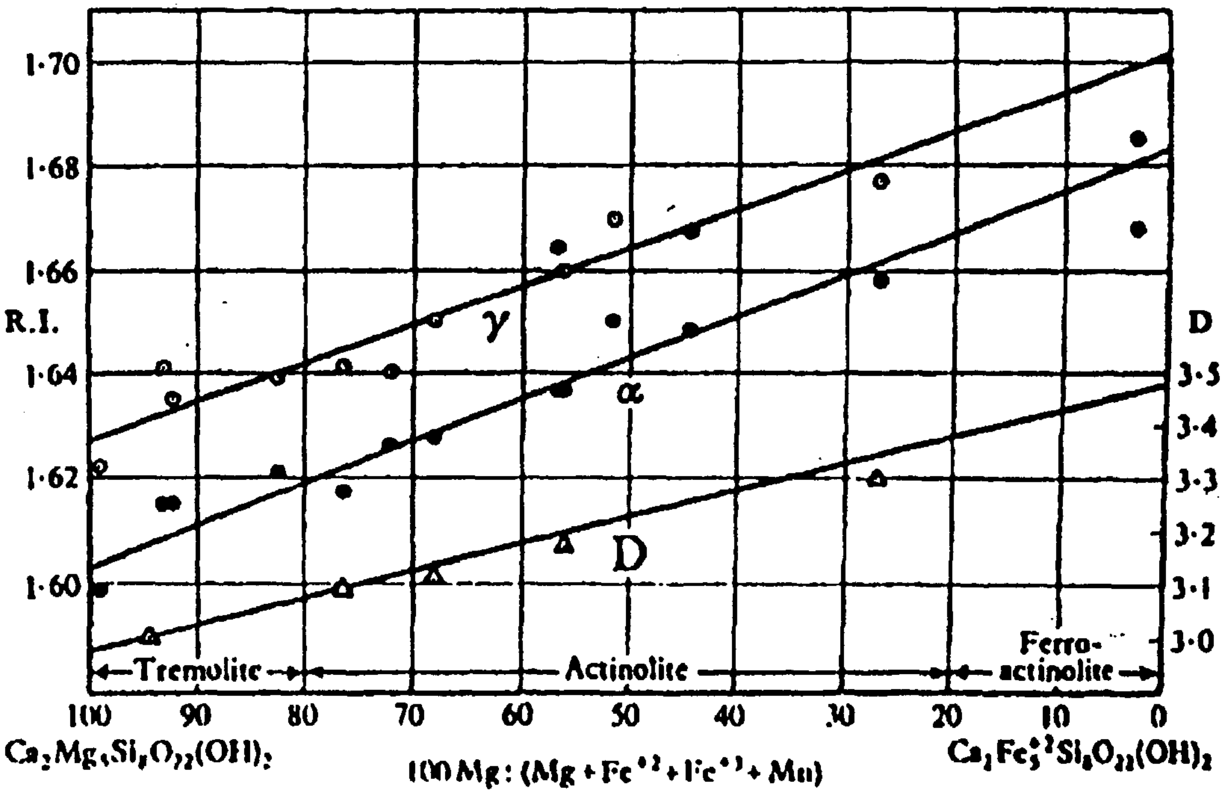

Figure 1. The relation between chemical composition and refractive indices and density of the tremolite-ferroactinolite series.

(Source: Howing. G. R. An Introduction to the Rock Forming Minerals)

Table 1. Results of Quantitative Analysis of Asbestos in Dust (micro-vac) by Transmission Electron Microscopy, El Dorado Hills-Shingle Springs, California, 6 September 1997.

Sample Number	SB05	SB06	SB07	SB08	SB10	SB11
Location	3329 Woedee Drive		3540 Cothrin Ranch Road		3893 Wild Turkey Drive	
	Living room	Above Front door	Ceiling beam	Above front door	Top of computer	Dining room
Area Sampled, cm^2	425.8	387.1	103.2	309.7	103.2	464.5
Volume filtered, ml	0.1	0.1	0.1	0.1	1.0	0.1
Effective filter area, mm^2	190	190	190	190	190	190
Grid Openings Area, mm^2	0.0074	0.0074	0.0074	0.0074	0.0074	0.0074
# Grid Openings Analyzed	15	30	15	20	25	30
Analytical Sensitivity, s/cm^2	4020	2211	16586	4145	995	1843
# Asbestos Structures Counted	15	10	28	1	9	6
Asbestos Concentration, s/cm^2	60300	22110	464408	4145	8955	11058
Asbestos type(s) detected	CH, AC	CH, AC	CH, AC*	AC	CH, AC*	CH/AC

* Ferroactinolite (non-asbestos) was also detected
Codes : CH (Chrysotile); AC (Tremolite-Actinolite series); ND (None Detected)
ASTM Standard Test Method D22.07.P008

Table 2. Results of Quantitative Analysis of Asbestos in Drinking Water by Transmission Electron Microscopy, 3893 Wild Turkey Drive,El Dorado Hills-Shingle Springs, California, 6 September 1997.

Sample Number	SB09
Volume filtered, ml	35.0
Effective filter area, mm^2	190
Grid Openings Area, mm^2	0.0074
# Grid Openings Analyzed	4
# Asbestos Fibers ≥10um	0
Analytical Sensitivity, MFL	0.18
Asbestos Concentration, ≥10um in length, MFL	<0.18
Asbestos type(s) detected	ND

Codes : CH (Chrysotile); ND (None Detected) MFL (Millions of Fibers per Liter)
* Method EPA-600/4-83-043

Table 3. Results of Quantitative Analysis of Asbestos in Bulk road dust Material by Transmission Electron Microscopy, Cothrin Ranch Road, El Dorado Hills- Shingle Springs, California, 6 September 1997.

Sample Number	Organic Wt (%)	Acid-Soluble Wt (%)	Asbestos Weight (%)	Asbestos Type(s)	Residue Weight (%)
SB15	1.4	4.0	0.0046	AC, CH	94.6

Legend:
AC (Tremolite-Actinolite)
CH (Chrysotile);

Method EPA-600/4-83-043

Table 4. Results of Quantitative Analysis of Asbestos in Air by Transmission Electron Microscopy , El Dorado Hills-Shingle, Springs, California, 6 September 1997.

Sample Number	Sample Location	Type of Sample	Sample Media	Flow Rate (liters/min)	Volume (liters)	Analytical Sensitivity	Structure per cc	Structures per mm²	Asbestos Type(s)
SB01	North edge of Property 3893 Wild Turkey Dr	Area Air Sample	25mm, 0.45um MCEF	9.0	2232	0.0023	0.0023	14	Chrysotile
SB02	South of Residence 3893 Wild Turkey Dr	Area Air Sample	25mm, 0.45um MCEF	8.75	2135	0.0024	0	0	ND
SB03	Family Room 3893 Wild Turkey Dr	Area Air Sample	25mm, 0.45um MCEF	10.0	2380	0.0021	0	0	ND
SB04	Yard - 3329 Woedee Dr	Area Air Sample	25mm, 0.45um MCEF	10.0	2470	0.0021	0.0042	27	Chrysotile
SB12	Side of Cothrin Ranch Road	Area Air Sample	25mm, 0.45um MCEF	3.013	141.6	0.0367	0.2204	81	Actinolite
SB13	Blank	Area Air Sample	25mm, 0.45um MCEF	0	1500	0	NA	NA	NA
SB14	Blank	Area Air Sample	25mm, 0.45um MCEF	0	0	0	NA	NA	NA

ND = Not Detected
NA = Not Analyzed

*Analytical Method: Yamate Level II

Forensic Analytical

FAX MEMO

DATE: 1/29/98

TO: CHRIS BOWMAN

COMPANY: SACRAMENTO BEE
916-321-1996

FAX#: 916-321-~~1069~~ 1109

FROM: MARK FLOYD

RE: EL DORADO COUNTY
FASI RN 273391

#PAGES: 3 (including coversheet)

MESSAGE:

Attached is a breakdown (by asbestos type) of the initial and normalized final results from asbestos analysis of samples from the referenced project. To reiterate the analytical procedures used in this project, the microvac samples were initially analyzed at ~20,00x magnfication to the limits specified by the reference method (ASTM Method 5755-95). Only one amphibole structure was counted in the six samples in the initial analysis.

Since it was expected that amphibole asbestos would be detected in all samples, we were requested to analyze additional grid openings until any amphiboles were detected. All six microvac samples were reanalyzed at reduced magnification (8800x), scanning for amphiboles only. Based on EDX spectra, actinolite (asbestos) and ferroactinolite (non-asbestos) were seen; no structures were detected that we would identify as tremolite.

Additional openings (up to 20) were scanned until at least one countable amphibole asbestos structure was detected. A total of 75 additional openings were counted. The asbestos counts from the first ten openings were normalized to the total number of openings counted and then added to the number of amphiboles counted, yielding the asbestos structure counts noted in the attached table.

Please call me at 510-887-8828 if you have any questions.

San Francisco Office: [illegible] Depot Road, Suite [illegible], Hayward, California [illegible] • Telephone [illegible] FASI Fax [illegible]
Los Angeles Office: [illegible] Pacific Commerce Drive, Rancho Dominguez, California [illegible] • Telephone [illegible] Fax [illegible]

Forensic Analytical

QUANTITATIVE ANALYSIS REPORT
ASBESTOS IN DUST (MICRO-VAC)
by Transmission Electron Microscopy*

San Joaquin Environmental
7257 N. Maple Avenue, Suite 108
Fresno, CA 93720

Page:	1/2
Client ID:	2968
Report Number:	273391
Date Received:	09/09/97
Date Reported:	12/02/97

Job #:	not specified
Site:	El Dorado County

Analyst:	BB,AC,MF
Date Analyzed:	10/20/97- 12/02/97

ASBESTOS-TYPE BREAKDOWN

Client Sample Number		SB05	SB06	SB07
20,000x magnification	#GO analyzed	10	10	10
	#Chrysotile	9	3	18
	#Actinolite	0	0	0
8,000x magnification	#GO analyzed	5	20	5
	#Actinolite	1	1	1
Normalization	#GO analyzed	15	30	15
	#Chrysotile	14	9	27
	#Actinolite	1	1	1
	#Asbestos	15	10	28
Area sampled, cm2		425.8	387.1	103.2
Volume filtered, ml		0.1	0.1	0.1
Effective filter area, mm2		190	190	190
Grid opening area, mm2		0.0074	0.0074	0.0074
Analytical sensitivity, s/cm2		4,020	2,211	16,586
Asbestos concentration, s/cm2		60,300	22,110	464,408

QUANTITATIVE ANALYSIS REPORT
ASBESTOS IN DUST (MICRO-VAC)
by Transmission Electron Microscopy*

San Joaquin Environmental		Page:	2/2
7257 N. Maple Avenue, Suite 108		Client ID:	2968
Fresno, CA 93720		Report Number:	273391
		Date Received:	09/09/97
		Date Reported:	12/02/97
Job #:	not specified	Analyst:	BB,AC,MF
Site:	El Dorado County	Date Analyzed:	10/20/97- 12/02/97

ASBESTOS-TYPE BREAKDOWN

Client Sample Number		SB08	SB10	SB11
20,000x magnification	#GO analyzed	10	10	10
	#Chrysotile	0	3	1
	#Actinolite	0	0	1
8,000x magnification	#GO analyzed	10	15	20
	#Actinolite	1	1	0
Normalization	#GO analyzed	20	25	30
	#Chrysotile	0	8	3
	#Actinolite	1	1	3
	#Asbestos	1	9	6
Area sampled, cm2		309.7	103.2	464.5
Volume filtered, ml		0.1	1.0	0.1
Effective filter area, mm2		190	190	190
Grid opening area, mm2		0.0074	0.0074	0.0074
Analytical sensitivity, s/cm2		4,145	995	1,843
Asbestos concentration, s/cm2		4,145	8,955	11,058

Forensic Analytical

FAX MEMO

DATE: 2/24/98

TO: CHRIS BOWMAN

ORG: SACRAMENTO BEE

FAX#: 916-321-1109
916-321-1996

FROM: MARK FLOYD

RE: EL DORADO COUNTY
FASI RN 273391

#PAGES: 1 (including coversheet)

MESSAGE:

At your request, I have reviewed the countsheet for an air sample in the referenced project. For Sample SB12, six actinolite and no additional asbestos structures were detected in the ten grid openings analyzed. Two structures, recorded as fibers, were over 5 microns in length: specifically, 10.2 and 19.5 microns. Unfortunately, the diameter of these fibers was not recorded, so it is unknown whether they would be counted as "OSHA fibers," which are greater than 0.25 micron in diameter.

The other four structures were between 2 and 3.5 microns long, inclusive, and were recorded as matrix structures. Each structure counted contributes 0.03674 to the s/cc concentration. The total asbestos concentration in this sample was calculated as 6 x 0.03674 = 0.2204 s/cc. If only the structures greater than 5 microns in length are considered, the asbestos concentration would be 2 x 0.03674 = 0.0735 s/cc.

Please call me at 510-887-8828 if you have any questions.

FAX MEMO

DATE: 1/29/98

TO: CHRIS BOWMAN

COMPANY: SACRAMENTO BEE

FAX#: 916-321-1109
916-321-1996

FROM: MARK FLOYD

RE: EL DORADO COUNTY
FASI RN 273391

#PAGES: 5 (including coversheet)

MESSAGE:

Attached are breakdowns (by asbestos type) of the results from asbestos analysis of air and bulk samples from the referenced project. No asbestos was detected in the water sample submitted with this project (SB09), so no breakdown is available.

The air samples were analyzed by the standard Yamate Level II procedure, in which all asbestos structures are counted that are greater than 0.2 microns long and have an aspect ratio of $\geq$ 3:1. Two of the samples contained no asbestos, two contained only chrysotile asbestos, and one contained only actinolite asbestos.

The bulk sample was analyzed using a modified EPA procedure in which the sample was gravimetrically reduced by ashing and acid-washing. The residue was suspended, aliquots were filtered, and the filters were mounted on TEM grids. In the analysis, large structures were counted at low magnification and small structures were counted at a higher mag. The asbestos concentration in the sample was calculated by first determining the volume of each asbestos structure counted and using magnification and density conversion factors to determine asbestos mass. The mass detected in the high magnification analysis was then normalized to the number of grid openings analyzed and the aliquot volume filtered for the low magnification analysis. Since a known residue mass was passed through a known filter area, and the filter area analyzed is known, the normalized asbestos mass in the residue can be determined, and then back-calculated to weight percent asbestos in the original sample. The attached table breaks down by asbestos type the number of structures counted, their mass, and their contribution to the calculated asbestos weight percent in the sample.

San Francisco Office · [illegible] Depot Road, Suite [illegible], Hayward, California [illegible] • Telephone [illegible] Fax [illegible]
Los Angeles Office · [illegible] Pacific Commerce Drive, Rancho Dominguez, California [illegible] • Telephone [illegible] Fax [illegible]

Forensic Analytical

QUANTITATIVE ANALYSIS REPORT
ASBESTOS IN AIR
by Transmission Electron Microscopy*

San Joaquin Environmental		Page:	1/1
7257 N. Maple Avenue, Suite 108		Client ID:	2968
Fresno, CA 93720		Report Number:	273391
		Date Received:	09/09/97
		Date Reported:	12/02/97
Job #:	not specified	Analyst:	BB,AC,MF
Site:	El Dorado County	Date Analyzed:	10/20/97- 12/02/97

ASBESTOS-TYPE BREAKDOWN

Client Sample Number	SB01	SB02	SB03	SB04	SB12
#Grid openings analyzed	10	10	10	10	10
#Chrysotile counted	1	0	0	2	0
#Actinolite counted	0	0	0	0	6
#Asbestos counted	1	0	0	2	6
Grid opening area, mm2	0.0074	0.0074	0.0074	0.0074	0.0074
Air volume sampled, L	2232	2135	2380	2470	141.6
Analytical sensitivity s/cc	0.0023	0.0024	0.0022	0.0021	0.0367
Asbestos concentration, s/cc	0.0023	<0.0024	<0.0022	0.0042	0.2202

Samples SB13 & SB14 were blanks and were not analyzed.

Forensic Analytical

QUANTITATIVE ANALYSIS REPORT
ASBESTOS IN BULK MATERIAL
by Transmission Electron Microscopy*

	Page:	**1/1**
San Joaquin Environmental	**Client ID:**	**2968**
7257 N. Maple Avenue, Suite 108	**Report Number:**	**273391**
Fresno, CA 93720	**Date Received:**	**09/09/97**
	Date Reported:	**12/02/97**

Job #:	not specified	**Analyst:**	**BB,AC,MF**
Site:	El Dorado County	**Date Analyzed:**	**10/20/97- 12/02/97**

ASBESTOS-TYPE BREAKDOWN

Client Sample Number		SB15
20,000x magnification	#GO analyzed	10
	#Chrysotile	11
	#Actinolite	0
2,650x magnification	#GO analyzed	20
	#Actinolite	5
Normalization	#GO analyzed	30
	#Chrysotile	33
	#Actinolite	8
	#Asbestos	41
	Actinolite mass, pg	7.3296
	Chrysotile mass, pg	0.1920
	Asbestos mass, pg	7.5216
Actinolite percent of mass		97
Chrysotile percent of mass		3
Actinolite concentration, weight %		0.0045
Chrysotile concentration, weight %		0.0001
Asbestos concentration, weight %		0.0046

Forensic Analytical

FAX MEMO

DATE: 11/18/97

TO: JASON ALLEN

COMPANY: SAN JOAQUIN ENVIRONMENTAL

FAX#: 209-298-9500

FROM: MARK FLOYD

RE: EL DORADO COUNTY
FASI RN 273391

#PAGES: 1 (including coversheet)

MESSAGE:

This memo provides the results of your request to reanalyze microvac samples from the referenced project. Specifically, you were expecting that amphibole asbestos would be detected in all samples and you wanted to investigate some of the samples that only appeared to contain chrysotile asbestos in the initial analysis.

Reanalysis of samples SB05, SB06, and SB07 was performed 11/17/97. Since amphibole structures are usually much larger than chrysotile, and since we figured we'd need to cover a lot of filter area, we scanned a 8800x (not the usual 20,000x). Tremolite and actinolite asbestos, as well as ferroactinolite (non-asbestos), were seen in these samples. The analyst estimates that there was approximately one of these fibers in 20-30 grid openings. Because we only ran ten grid openings in the initial analyses (as required by the method), it is understandable how we only saw one amphibole structure in the six samples in this set.

Please call me at 510-887-8828 if you have any questions.

San Joaquin Environmental Inc.

Environmental Health, Industrial Hygiene, and Occupational Safety Services

7257 N. Maple Avenue, Fresno, CA 93720 • Tel: (209) 298-8500 • Fax: (209) 298-9500

fax

to: CHRIS BOWMAN

company: SACRAMENTO BEE

fax #: 916 [illegible] 987 8828

from: CHRIS TENNANT

date: 11/18/97

subject:

pages: including cover sheet

NOTES:

San Joaquin Environmental Inc.

Environmental Health, Industrial Hygiene, and Occupational Safety Services

7257 N. Maple Avenue, Fresno, CA 93720 • Tel: (209) 298-8500 • Fax: (209) 298-9500

fax

to: CHRIS BOWMAN

company: SACRAMENTO BEE

fax #: 916 321 1109

from: CHRIS TENNANT

date: 2-5-98

subject:

pages: including cover sheet

NOTES: Chris,
The word "actinolite" used by forensics on their report means "Tremolite-Actinolite series (see report). I changed it on Table 4 but where ever you see actinolite reported it means Tremolite-actinolite as per Mark Floyd.

Forensic Analytical

11 February 1998

Mr. Chris Bowman
Environmental Writer
Sacramento Bee
2100 Q Street
Sacramento, CA 95816

RE: Eldorado Hills Photomicrographs
FASI SP# 98007

Dear Chris:

Enclosed are three photomicrographs of asbestos structures detected in dust samples from the referenced project. Each photo is numbered on the back and described on the attached page.

Please call me at 510-887-8828 if you have any questions.

Sincerely,

Mark Floyd
Electron Microscopy Supervisor

San Francisco Office: 3777 Depot Road, Suite 409, Hayward, California 94545 • Telephone: 510/887-8828 800/827-FASI Fax: 510/887-4218
[illegible] Pacific Commerce Drive Rancho Dominguez, California 90221 • Telephone: 310/763-2374 Fax: 310/763-8684

Forensic Analytical

PHOTOMICROGRAPH LOG
ASBESTOS IN DUST (MICRO-VAC)
by Transmission Electron Microscopy

San Joaquin Environmental
7257 N. Maple Avenue, Suite 108
Fresno, CA 93720

Page:	1/1
Client ID:	2968
Report Number:	273391
Date Received:	09/09/97
Date Reported:	02/11/98

Job #:	not specified	Analyst:	MF
Site:	El Dorado County	Date Analyzed:	02/11/98

PHOTO#	MAGNIFICATION*	BAR LENGTH, microns**	PHOTO DESCRIPTION
1	10,000	5	Actinolite fiber from sample SB05 (Bolander residence, shelf between living rm and kitchen). Fiber is ~6.25 microns long and 0.75 microns across. Note: 2 chrysotile fibers (each <1 micron long) are also present.
2	10,000	5	Chrysotile fibers from sample SB07 (Beck residence, on ceiling beam. Longest fiber is approx. 7 microns long and 0.1 micron across.
3	5,000	10	Actinolite fiber from sample SB15 (unpaved road dust). Fiber is approx. 9 microns long and 0.5 microns across.

* Magnifications listed are for the 3.25 x 4 inch negative. Mags on 8 x 10 enlargements are 2.5 times greater.

** BAR refers to the white line across the bottom of each image which serves as a measurement scale.

G:\PUBLIC\TEM\WPREPORT\273391TM.SJE

RESUME

Christopher J. Tennant PhD., CIH., REA

7257 North Maple Avenue #108
Fresno, California 93720

Tel: (209) 298-8500
FAX: (209) 298-9500
Email: chris_tennant@csufresno.edu

EDUCATION

1984	University of Aston in Birmingham, UK, Department of Environmental and Occupational Health, Doctor of Philosophy (PhD).
1981	Plymouth Polytechnic, Plymouth, UK, Department of Environmental Science, Bachelor of Science (BS), Specialism: Pollution Studies.

APPOINTMENTS

1993 - Present	Professor, Environmental Health/Industrial Hygiene, Department of Health Science, California State University, Fresno, California.
1986 - 1993	Associate Professor, Environmental Health/Industrial Hygiene, Department of Health Science, California State University, Fresno, California.
1985 - 1986	Manager, Environmental Advisory Unit, Wardell Armstrong Consultants, Newcastle-under-Lyme, UK.
1984 - 1985	Postgraduate Research Fellow, Health and Safety Unit, Department of Chemical Engineering, University of Aston in Birmingham, UK.
1982 - 1984	Lecturer, Department of Environmental and Occupational Health, University of Aston in Birmingham, UK.

PROFESSIONAL SOCIETIES

American Board of Industrial Hygiene (ABIH).
    Member 1991 - Present.
American Industrial Hygiene Association (AIHA).
    Member 1988 - Present.
    Toxicology Committee, 1990 - ~~Present~~. 1996
    Computer Applications Committee, 1990 - ~~Present~~. 1996
    Proficient Analyst, Proficiency Analytical Testing (PAT) Program.
        1988 - ~~Present~~. 1994

Central California Chapter (AIHA) Member 1990 - ~~Present~~ 1996.
President 1992, 1993
President Elect 1991,
Founder Member 1990.
American Conference of Governmental Industrial Hygienists (ACGIH).
Member 1988 - Present.
National Environmental Health Association (NEHA)
Member 1986 - 1991
Epidemiological Technical Committee, 1987 -1990.
Environmental Toxicology Committee, 1987 - 1990.
Hazardous Materials Emergency Management Committee, 1987 - 1990.
Occupational Health Committee, 1987 - 1990.

DESIGNATIONS

AHERA Accredited Building Inspection and Management Planning for Asbestos

AHERA Accredited Contract Supervisor

AHERA Accredited Asbestos Abatement Project Designer

Certified Industrial Hygienist (CIH), Comprehensive Practice, American Board of Industrial Hygiene (ABIH).

Certified Asbestos Consultant (CAC), State of California Division of Occupational Safety and Health (DOSH) Cal/OSHA.

Registered Environmental Assessor (REA), State of California Registration # 02238.

Certified Lead-Related Construction Project Monitor, California Department of Health Services (DHS), Childhood Lead Poisoning Prevention Branch.(Interim).

Certified Lead-Related Construction Supervisor, California Department of Health Services (DHS), Childhood Lead Poisoning Prevention Branch. (Interim).

Certified Lead Related Construction Inspector/Assessor, California Department of Health Services (DHS), Childhood Lead Poisoning Prevention Branch.(Interim).

Certified Lead Related Construction Project Designer, California Department of Health Services (DHS), Childhood Lead Poisoning Prevention Branch.(Interim).

Licensed XRF Operator, California Department of Health Services, Radiologic Health Branch.

Forensic Analytical

- Fax Cover Sheet -

Date: 3/14/97

Pages: 3

To: Chris Bowman, Sacramento Bee

Fax Phone: 916-321-1996

From: David Kahane

Subject: Brief History Summary & Resume

THIS IS FORENSIC ANALYTICAL

Answers to your questions...Solutions to your problems!

Forensic Analytical is an analytical laboratory and consulting firm specializing in the industrial hygiene and environmental health sciences. Founded in 1984, Forensic Analytical has become recognized as one of the highest quality specialty firms on the west coast. With experienced staff in both the lab and the field, Forensic Analytical is in a unique position to provide specialty consulting and analytical support to clients as well as providing project support to firms who may wish to augment in-house capabilities.

Our Environmental Services Division specializes in the identification and management of asbestos, lead, and other hazardous materials found in industrial and commercial facilities. Asbestos consulting services are provided by consultants and site surveillance technicians certified by the state of California. Industrial hygiene services are overseen by David Kahane, CIH, and owner of Forensic Analytical.

Forensic Analytical's in-house analytical capabilities include optical and electron microscopy, and atomic absorption (AA), inductively coupled plasma (ICP) and micro-FTIR spectroscopy. Our Laboratory Services Division provides a range of environmental and industrial hygiene analytical services. Forensic Analytical's laboratories are accredited by NVLAP, CA OHS, and AIHA.

Consulting Services

- Hazard Evaluations
- Asbestos Surveys
- XRF Lead Surveys
- O & M Program Development
- Specification Development
- Health & Safety Program Development
- Forensic Consulting

Project Management Services

- Complete Project Management
- Contractor Selection Assistance
- Air Monitoring
- Abatement Observation
- Work Practices Documentation

Laboratory Services

- Optical Microscopy (PCM/PLM)
- Electron Microscopy (TEM/SEM)
- AA/ICP/micro-FTIR Spectroscopy
- Particle Identification
- Material Characterization
- Specialty Laboratory Consulting
- Trace Evidence Analysis

Specialty Services

- Indoor Air Quality Studies
- Industrial Hygiene Monitoring
- OSHA Compliance Audits
- Bioaerosol Sampling
- Legal Consultation/Case Review

FORENSIC ANALYTICAL

3777 Depot Road, #409
Hayward, CA 94545
800-827-3274

2959 Pacific Commerce Drive
Rancho Dominguez, CA 90221
310-763-2374

Forensic Analytical
San Francisco • Los Angeles

DAVID KAHANE, CIH

Principal/Director of Laboratory Services
Laboratory Services Division

EDUCATION

M.P.H., Environmental Health Sciences, UC Berkeley, 1982
B.A., Physiology, UC Berkeley, 1980

CERTIFICATIONS AND REGISTRATIONS:

Certified Industrial Hygienist #5549, American Board of Industrial Hygiene

SHORT COURSES

Comprehensive Review of Industrial Hygiene, Rocky Mountain Center for Occupation and Environmental Health, 1989
NIOSH 582 Asbestos Identification and Sampling, University of North Carolina at Chapel Hill, 1983
Forensic Microscopy, McCrone Research Institute, Chicago, Illinois, 1981

PROFESSIONAL EXPERIENCE

Founder and principal of Forensic Analytical. Manages daily laboratory operations and customer service functions. Oversees all aspects of marketing and new business development. Technical expertise in litigation support for asbestos cases, research on dioxins and furans generated during fires, and pesticide surveys. Performs industrial hygiene and indoor air quality investigations for a variety of military, commercial and school clients. On-site monitoring of airborne asbestos, statistical evaluation of asbestos survey data, and experimental design for indoor asbestos exposure assessment. Analysis of airborne fibers and bulk materials for asbestos concentrations.

Survey design and statistical analysis of custodial worker's exposure to asbestos reentrainment at San Francisco Federal Building. Twenty four hour real time monitoring of asbestos to examine fluctuations in airborne concentrations in indoor environment. Experience in routine analysis of PCBs and pesticides in biological tissue, transformer oils, air, and soil. Routine analysis of formaldehyde and asbestos. Analysis of steroid and protein antigens in human, monkey, rat, and mouse tissues by radioimmunoassay; antibody purification and titration methodologies.

PROFESSIONAL AFFILIATIONS

Board of Directors, Lead Solutions, 1993-1994
Board of Directors, National Environmental Information Association, 1993-Present
Board of Directors, California Environmental Information Association, 1991-1993
American Society for Testing Materials, Member, 1992-Present

American Industrial Hygiene Association, Member 1992-Present
American Academy of Forensic Sciences, Member, 1980-Present
Steel Structures Painting Council, Member 1992-Present
Cal OSHA Lead Advisory Board, Participant
U.C. Berkeley Center for Environmental Management, Lecturer

PUBLICATIONS AND PRESENTATIONS

D. R. Van Orden, R. J. Lee, K. M. Bishop, D. Kahane, R. Morse, "Evaluation of Ambient Asbestos Concentrations in Buildings Following the Loma Prieta Earthquake," Regulatory Toxicology and Pharmacology, 21, 117-122, 1995.

Jim Millette, David Kahane, Bruce White, "Contamination from Asbestos Dust: How Much is Too Much," presented at Environmental Information Association's 1994 Fall Regional Conferences, Las Vegas, NV, November, 1994.

Moderator/Lecturer, Environmental Information Association, Lead Symposium, San Diego, California (1994) and Tampa, Florida (1995).

D. Kahane, J. Teichman, D. Coltrin, K. Prouty, "A Survey of Lead Contamination in Soil Along Interstate 880, Alameda County, California," presented at Lead Tech '92, Bethesda, MD, October, 1992.

David Kahane, "Asbestos Testing and Building Owner Liability", San Francisco Business Times (The Hidden Building), 1988.

David Kahane and John Thornton, "Determination of the Absolute Density of Glass following the Sink-Float Method," Journal of Forensic Science, 32 (1) 87-92, January 1987.

J. Thornton, S. Kraus, B. Lerner, and D. Kahane, "Solubility Characterization of Automotive Paints." Journal of Forensic Science, 28 (4) 1004-1007, October 1983.

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Expires 6/04/97 at 16:06
Guide E-Mail. Subject : asbestos

<A1>E-mail from: Day@topaz.ucdavis.edu
Subject: asbestos

May 5

Hi Chris,

I was finally able to obtain some time on the instrument I needed. There is no doubt that both samples I picked up at Terry Trent's are asbestos-form amphibole. The x-ray diffraction data clearly identify the amphibole structure. Our back-scattered electron images confirm that they have asbestos-form habit (1 micron wide; 50 microns long), which can clearly be seen by looking at the hand sample. The qualitative chemical analysis we did is consistent with amphibole chemistry and the optical properties (refractive index) rule out the possibility that the asbestos is a form of serpentine.

There is no question that this is amphibole asbestos.

If I can be further help, please let me know.

Regards

Howard

****
Howard W. Day
Dept. of Geology
UC Davis
Davis, CA 95616

day@geology.ucdavis.edu
TEL: 916-752-2882
FAX: 916-752-0951
****
"Diplomacy is knowing how to say good doggie...
until you can find a big enough rock."

Attributed to Teddy Roosevelt.
****

[illegible] images\schiffma\raf1.hmx 22-1-1997 [illegible]

Acquisition size : 256,256

Acquisition type : Beam

Beam Current : 16.4 nA, Acc. Voltage : 15.0 kV, Mag. : 1000.0

X-Ray : Time = 5.000 ms, NbFrm = 1

Video : NbPix = 10, NbFrm = 2

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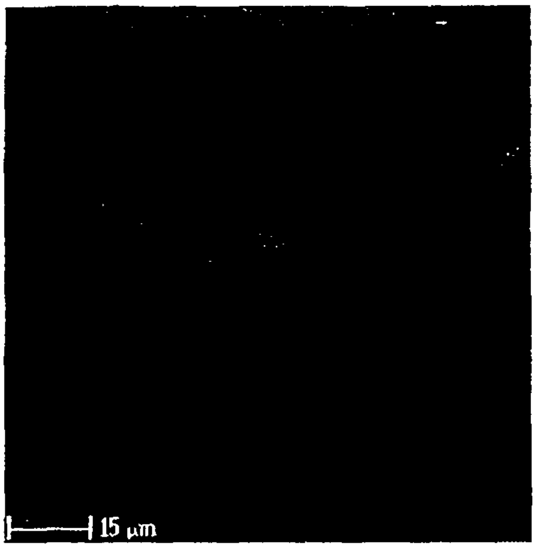

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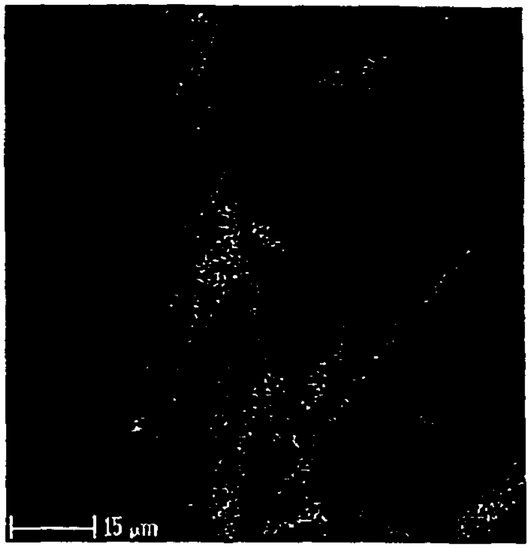

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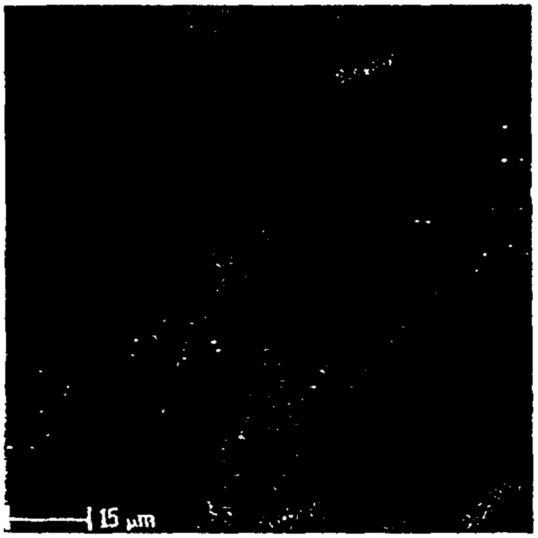

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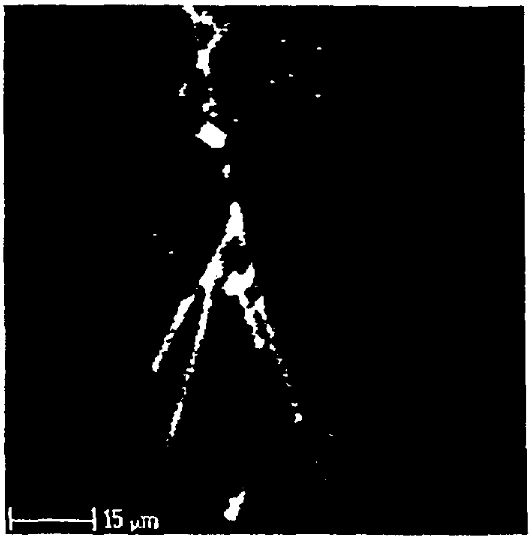
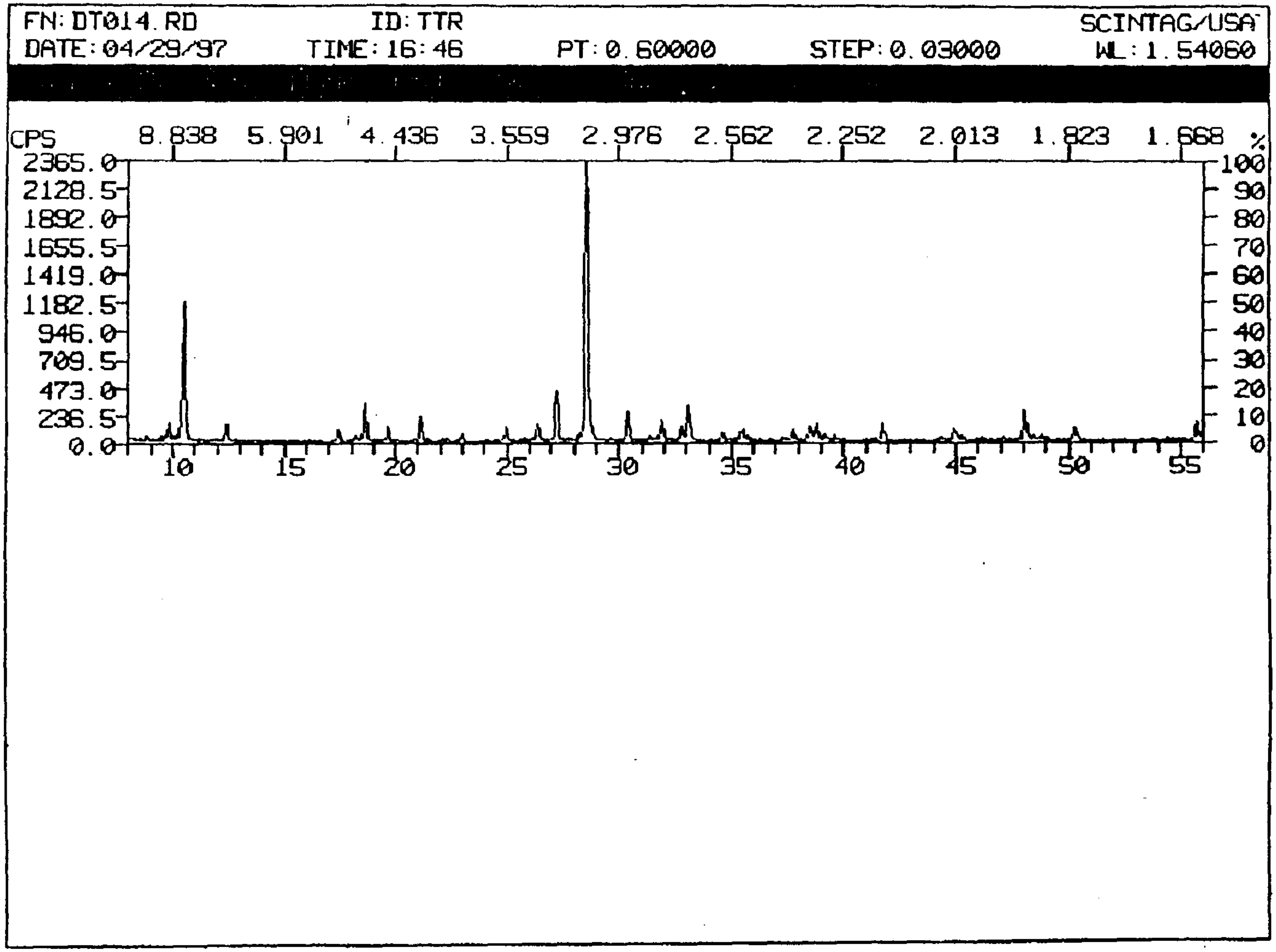




FN: DT014.RD ID: TTR SCINTAG/USA
DATE: 04/29/97 TIME: 16:46 PT: 0.60000 STEP: 0.03000 WL: 1.54060

Cancer Surveillance Program
Region 3

A Program of
Sutter Cancer
Center

2800 L Street, Suite 440
Sacramento
CA 95816-5600
(916) 454-6522
FAX 454-6523

September 16, 1997

Chris Bowman
Sacramento Bee
2100 Q Street
Sacramento, CA 95816

Dear Mr. Bowman;

The Cancer Surveillance Program, as Region 3 of the California Cancer Registry, collects information about cancer diagnosed among the approximately 2.9 million residents of 13 counties in the Sacramento area. One of the uses of cancer registry data is to monitor incidence of cancer in an area, and to assess whether the number of new cancer cases is greater than the number that would be expected for the population. I have completed an analysis of cancer incidence in western El Dorado County as you requested. This analysis focused on the number of mesothelioma cases.

The census tract is the geographic division for which we have detailed 1990 population data and is the unit that we usually use to assess cancer incidence. Based on the information you gave me, I included twenty census tracts that included all of the population of the western slope of El Dorado County. These tracts included the towns of Placerville, Diamond Springs, Pollock Pines, Shingle Springs, Cameron Park, El Dorado Hills, Georgetown, Cool and Garden Valley. Because there is a lag time between cancer diagnosis and reporting by the hospital or physician to the registry, we currently have complete information on patients diagnosed through 1995. We examined cancer incidence in these census tracts for the eight-year period 1988-1995 and identified 17 cases of mesothelioma, located in the pleura, diagnosed among residents. The age range of patients was 59 to 85 and they lived in various locations around the county, although none resided in El Dorado Hills. There were approximately two to three cases diagnosed per year between 1988 and 1995.

To estimate the number of cases of mesothelioma of the pleura that would be expected to occur during this eight-year period, we applied the 1988-1992 annual average sex-, race-, and age-specific rates of cancer for the Sacramento region to the corresponding 1990 population of the 20 census tracts. Our calculations showed that in this population during eight years we would expect to see approximately 10 cases of this cancer. Although the number of cases observed was slightly greater than the number of cases expected, these results were within the range of what would be expected by chance. In addition, we know that the population of El Dorado County increased approximately 15% between 1990 and 1995, and this would increase the number of cancer cases that we would expect.

Appendix E-6

Air Resources Board
Draft Weaverville Road Study

Air Resources Board

Barbara Riordan, Chairman
2020 L Street · P.O. Box 2815 · Sacramento, California 95812 · www.arb.ca.gov

Winston H. Hickox
Secretary for Environmental Protection

Gray Davis
Governor

MEMORANDUM

TO: Todd Wong, Manager
Emissions Assessment Branch
Stationary Source Division

FROM: Michael Spears, Manager
Evaluation Section
Monitoring and Laboratory Division

DATE: May 13, 1999

SUBJECT: PRELIMINARY RESULTS OF AIRBORNE ASBESTOS MONITORING, PERFORMED OCTOBER 20 - 23, 1999, NEAR WEAVERVILLE CALIFORNIA

As requested in your PES note sent last summer (1998) we have completed the airborne asbestos monitoring south of Weaverville for the North Coast Air Quality Management District. This memo contains the preliminary results of this sampling program. Staff conducted the monitoring from October 20, 1998 through October 23, 1998. ARB and District Staffs chose six sampling sites. Staff took a total of 48 samples and two blanks. The highest concentration measured was 0.0232 fibers per cubic centimeters.

Each sampling site had two 24-hour samplers and a meteorological station. The two 24-hour samplers were co-located to set precision of the results. Meteorological stations measure and record wind speed and direction. Directional samplers were set up at the sampling site called "stream" and at the sampling site called "rest area." The STREAM site was north of the north entrance of the inactive quarry. The RESTAREA site was about a mile due south of the quarry. The directional samplers were set up to collect an air sample from a designated direction. One sampler sampled air that did not come from the direction of the quarry. The second directional sampler was set up to collect air coming from the direction of the quarry.

The attached map shows the location of sampling sites (Attachment 1a). A Magellan GPS Tracker determined longitude and latitude (Attachment 1b) of each sampling site. The accuracy of the nonmilitary GPS is poor. Ten GPS readings taken at one location over time can better define a location. Staff took only one reading at each site for the Weaverville monitoring program. The GPS locations in Attachment 1a were adjusted using a topographical map. Site photographs are available upon request.

Attachment 2a contains a listing of the samples collected. The measured concentrations for the samples is reported in Attachment 2b. We have reported the results for all fibers and those fibers greater than 5 microns in length. The results in Attachment 2b should not be put on the ARB Web Page since the names of private residences are listed.

A meteorological station was set up at each sampling site. Wind roses for each sampling period and site are found in Attachment 3. The raw data is in electronic form and is available electronically.

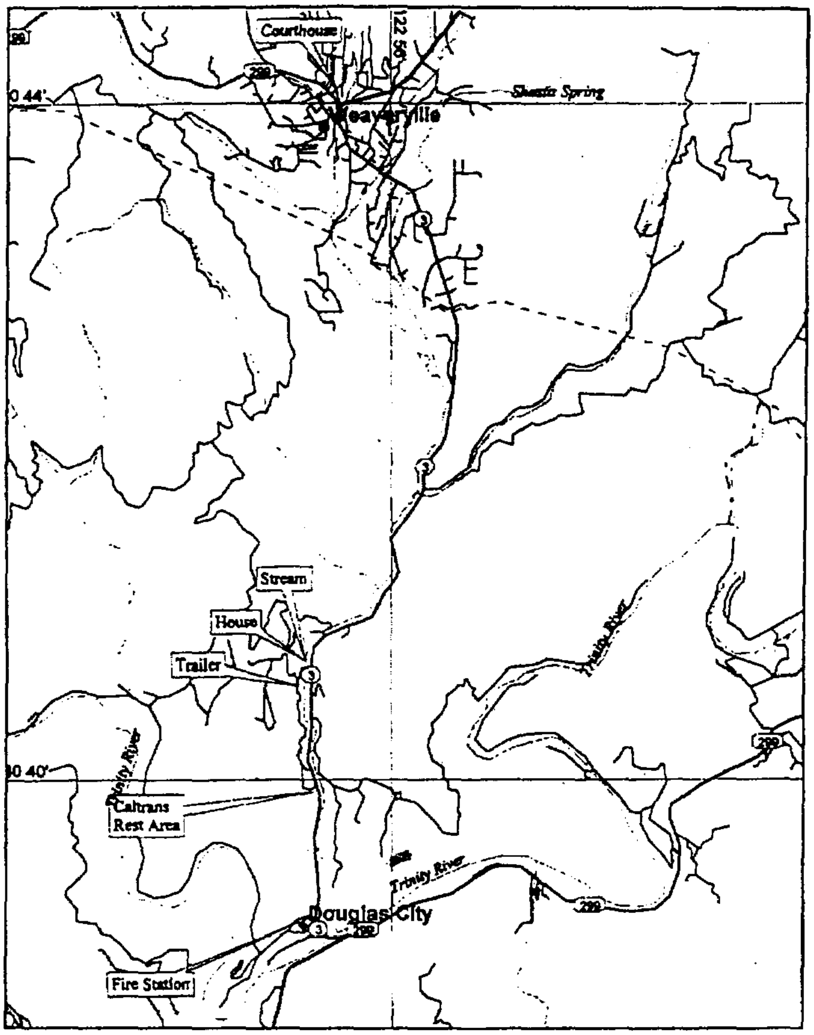
In the past, you have requested the fiber dimension data. The computer generated count sheets contains this information. The count sheets are part of the RJ Lee report contained in Attachments.

If you have suggestions or comments or need further information, please contact me at 263-1627 or have your staff contact James McCormack at 263-2060.

Attachments (4)

ATTACHMENT 1a

Sampling Locations



ATTACHMENT 1b

Longitude and Latitude of Sampling Sites

Site #	Sampling Location	longitude	latitude	longitude	latitude
		Degrees-Minutes	Degrees-Minutes	Degrees	Degrees
1	Stream	40° 40.71N	122° 56.68W	40.67850N	122.94333W
2	House	40° 40.71N	122° 56.71W	40.67850N	122.94500W
3	Trailer	40° 40.63N	122° 56.60W	40.67717N	122.94333W
4	Rest Area	40° 39.93N	122° 56.60W	40.66550N	122.94333W
5	Fire Station	40° 39.11N	122° 56.58W	40.65183N	122.94167W
6	Court House	40° 44.07N	122° 56.46W	40.73450N	122.94000W

ATTACHMENT 2a
Sample Log

		Start				End				
Log	Sample			Flow		Flow		Sampler		
#	ID	Date	Time	rate	ETM	rate	ETM	#	Comments	Site Name
TRI-1	WS1-1	10/20	9:15 AM	3.00	918.73	3.17	942.72	959		stream
TRI-2	WS2-1	10/20	9:15 AM	3.00	936.03	3.00	960.02	255		stream
TRI-3	WSN-1	10/20	9:30 AM	9.0	35.7	9.0	57.2	5		stream
TRI-4	WSS-1	10/20	9:30 AM	9.0	162.8	8.5	165.3	5		stream
TRI-5	WH1-1	10/20	9:45 AM	3.00	1190.05	3.00	1213.99	917		house
TRI-6	WH2-1	10/20	9:45 AM	3.00	1208.17	3.00	1232.1	918		house
TRI-7	TLR1-1	10/20	10:30 AM	3.00	1802.67	3.00	1826.66	958		trailer-power pole
TRI-8	TLR2-1	10/20	10:30 AM	3.00	1144.22	2.86	1168.21	957		trailer-power pole
TRI-9	RA1-1	10/20	11:15 AM	3.00	926.97	2.82	950.96	852		rest area
TRI-10	RA2-1	10/20	11:15 AM	3.00	257.31	2.95	281.3	337		rest area
TRI-11	RAN-1	10/20	11:15 AM	9.0	6	10.3	17.9	2		rest area
TRI-12	RAS-1	10/20	11:15 AM	9.0	211.1	10.3	223.1	2		rest area
TRI-13	FS1-1	10/20	12:15 PM	3.00	1775.05	3.00	1799.05	916		fire station
TRI-14	FS2-1	10/20	12:15 PM	3.00	1841.01	3.00	1865	960		fire station
TRI-15	CH1-1	10/20	1:30 PM	3.00	1028.51	2.97	1052.5	956		court house
TRI-16	CH2-1	10/20	1:30 PM	3.00	1365.98	2.95	1376.75	589		court house
TRI-17	WS1-2	10/21	9:15 AM	3.00	1747.98	3.00	1771.97	252		stream
TRI-18	WS2-2	10/21	9:15 AM	3.00	1867.18	3.17	1891.19	961		stream
TRI-19	WSN-2	10/21	9:45 AM	9.0	57.2	8.0	76.3	5		stream
TRI-20	WSS-2	10/21	9:45 AM	9.0	165.2	8.7	170.2	5		stream
TRI-21	WH1-2	10/21	9:30 AM	3.00	1071.03	3.20	1095.02	257		house
TRI-22	WH2-2	10/21	9:30 AM	3.00	703.5	3.20	727.49	248		house
TRI-23	TLR1-2	10/21	10:45 AM	3.00	960.02	2.94	984.01	255		trailer-power pole
TRI-24	TLR2-2	10/21	10:45 AM	3.00	942.72	2.94	966.71	959		trailer-power pole
TRI-25	RA1-2	10/21	11:30 AM	3.00	1232.11	3.10	1256.1	918		rest area
TRI-26	RA2-2	10/21	11:30 AM	3.00	1401.63	3.00	1425.62	245		rest area
TRI-27	RAN-2	10/21	11:45 AM	9.0	17.9	8.2	35	2		rest area
TRI-28	RAS-2	10/21	11:45 AM	9.0	223.1	8.8	229.9	2		rest area
TRI-29	FS1-2	10/21	12:30 PM	3.00	1168.21	2.88	1192.21	957		fire station
TRI-30	FS2-2	10/21	2:50 PM	3.00	1826.68	3.10	1848.14	958	1st sampler died	fire station
			12:30 PM	3.00	950.96		951.41	852		
TRI-31	CH1-2	10/21	1:15 PM	3.00	1865	3.00	1888.99	960		court house
TRI-32	CH2-2	10/21	1:15 PM	3.00	281.31	2.70	305.3	337		court house
TRI-33	WS1-3	10/22	9:15 AM	3.00	1052.5	2.93	1076.49	956		stream
TRI-34	WS2-3	10/22	9:15 AM	3.00	704.16	2.94	728.15	254		stream
TRI-35	WSN-3	10/22	9:45 AM	9.0	76.3	5.7	96.5	5		stream
TRI-36	WSS-3	10/22	9:45 AM	9.0	170.2	8.9	173.9	5		stream
TRI-37	WH1-3	10/22	9:15 AM	3.00	1214.02	3.17	1231.97	917		house
TRI-38	WH2-3	10/22	9:15 AM	3.00	1799.07	2.93	1823.03	916		house
TRI-39	TLR1-3	10/22	10:30 AM	3.00	1771.98	2.91	1795.97	252		trailer-power pole
TRI-40	TLR2-3	10/22	10:30 AM	3.00	1095.02	2.91	1119.01	257		trailer-power pole
TRI-41	RA1-3	10/22	11:15 AM	3.00	984.01	2.96	1008	255		rest area
TRI-42	RA2-3	10/22	11:15 AM	2.96	966.7	3.00	990.7	959		rest area
TRI-43	RAN-3	10/22	11:45 AM	9.0	35	7.2	49.9	2		rest area
TRI-44	RAS-3	10/22	11:45 AM	9.0	229.9	8.3	238.8	2		rest area
TRI-45	FS1-3	10/22	12:15 PM	3.00	1256.1	3.00	1280.09	918		fire station
TRI-46	FS2-3	10/22	12:15 PM	3.00	1425.62	2.95	1449.61	245		fire station
TRI-47	CH1-3	10/22	1:15 PM	3.00	1891.2	2.83	1915.19	961		court house
TRI-48	CH2-3	10/22	1:15 PM	3.00	727.5	2.91	751.49	248		court house
TRI-49	BUDS-2	10/22	12:15 PM	3.00	0	3.00	24		box blank	
TRI-50	BUDS-1	10/22	12:15 PM	3.00	0	3.00	24	956	field blank	

Notes: ETM is the acronym for Elapsed Time Meter

Sampling time is the difference in the ETM readings in units of hours.

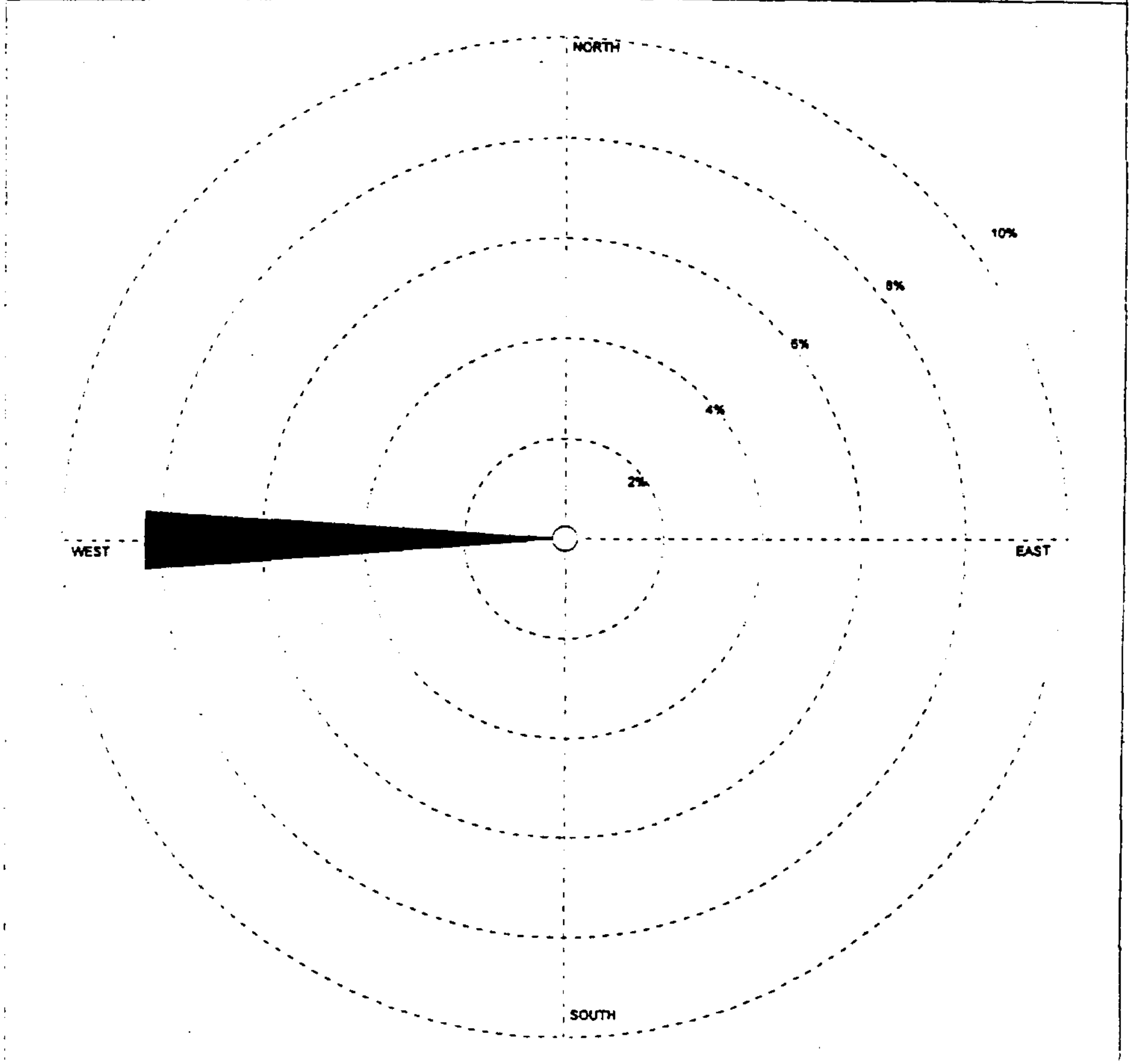
Attachment 2b
Results of Airborne Asbestos Monitoring

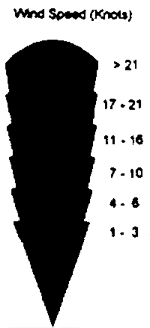
Log Number	Sample Number	Sampling Period	Sampling Location	MDL (S/cc)	Concentration Measured	
					All Fibers (S/cc)	>=5um (S/cc)
TRI-15	CH1-1	10/20 - 10/21/98	Court House - sampler 1	0.0010	ND	ND
TRI-16	CH2-1	10/20 - 10/21/98	Court House - sampler 2	0.0022	ND	ND
TRI-31	CH1-2	10/21 - 10/22/98	Court House - sampler 1	0.0010	ND	ND
TRI-32	CH2-2	10/21 - 10/22/98	Court House - sampler 2	0.0010	ND	ND
TRI-47	CH1-3	10/22 - 10/23/98	Court House - sampler 1	0.0010	ND	ND
TRI-48	CH2-3	10/22 - 10/23/98	Court House - sampler 2	0.0010	0.0010	0.0010
TRI-13	FS1-1	10/20 - 10/21/98	Fire Station - sampler 1	0.0010	ND	ND
TRI-14	FS2-1	10/20 - 10/21/98	Fire Station - sampler 2	0.0010	ND	ND
TRI-29	FS1-2	10/21 - 10/22/98	Fire Station - sampler 1	0.0010	0.0010	ND
TRI-30	FS2-2	10/21 - 10/22/98	Fire Station - sampler 2	0.0010	0.0010	0.0010
TRI-45	FS1-3	10/22 - 10/23/98	Fire Station - sampler 1	0.0010	ND	ND
TRI-46	FS2-3	10/22 - 10/23/98	Fire Station - sampler 2	0.0010	ND	ND
TRI-9	RA1-1	10/20 - 10/21/98	Rest Area - sampler 1	0.0010	0.0050	0.0010
TRI-10	RA2-1	10/20 - 10/21/98	Rest Area - sampler 2	0.0010	0.0029	ND
TRI-25	RA1-2	10/21 - 10/22/98	Rest Area - sampler 1	0.0010	0.0019	ND
TRI-26	RA2-2	10/21 - 10/22/98	Rest Area - sampler 2	0.0010	0.0087	ND
TRI-41	RA1-3	10/22 - 10/23/98	Rest Area - sampler 1	0.0010	ND	ND
TRI-42	RA2-3	10/22 - 10/23/98	Rest Area - sampler 2	0.0010	0.0010	ND
TRI-11	RAN-1	10/20 - 10/21/98	Rest Area - sampler facing north	0.0006	0.0012	0.0006
TRI-12	RAS-1	10/20 - 10/21/98	Rest Area - sampler facing south	0.0006	0.0006	0.0006
TRI-27	RAN-2	10/21 - 10/22/98	Rest Area - sampler facing north	0.0005	0.0038	0.0009
TRI-28	RAS-2	10/21 - 10/22/98	Rest Area - sampler facing south	0.0012	0.0023	ND
TRI-43	RAN-3	10/22 - 10/23/98	Rest Area - sampler facing north	0.0006	ND	ND
TRI-44	RAS-3	10/22 - 10/23/98	Rest Area - sampler facing south	0.0009	ND	ND
TRI-7	TLR1-1	10/20 - 10/21/98	Telephone Pole at Trailer - sampler 1	0.0010	ND	ND
TRI-8	TLR2-1	10/20 - 10/21/98	Telephone Pole at Trailer - sampler 2	0.0010	0.0089	ND
TRI-23	TLR1-2	10/21 - 10/22/98	Telephone Pole at Trailer - sampler 1	0.0010	0.0078	ND
TRI-24	TLR2-2	10/21 - 10/22/98	Telephone Pole at Trailer - sampler 2	0.0010	0.0010	ND
TRI-39	TLR1-3	10/22 - 10/23/98	Telephone Pole at Trailer - sampler 1	0.0010	ND	ND
TRI-40	TLR2-3	10/22 - 10/23/98	Telephone Pole at Trailer - sampler 2	0.0010	0.0010	ND
TRI-5	WH1-1	10/20 - 10/21/98	Wallace Home - sampler 1	0.0010	ND	ND
TRI-6	WH2-1	10/20 - 10/21/98	Wallace Home - sampler 2	0.0010	0.0010	ND
TRI-21	WH1-2	10/21 - 10/22/98	Wallace Home - sampler 1	0.0009	ND	ND
TRI-22	WH2-2	10/21 - 10/22/98	Wallace Home - sampler 2	0.0009	ND	ND
TRI-37	WH1-3	10/22 - 10/23/98	Wallace Home - sampler 1	0.0013	ND	ND
TRI-38	WH2-3	10/22 - 10/23/98	Wallace Home - sampler 2	0.0010	ND	ND
TRI-1	WS1-1	10/20 - 10/21/98	Stream at Wallace Home - sampler 1	0.0009	0.0028	ND
TRI-2	WS2-1	10/20 - 10/21/98	Stream at Wallace Home - sampler 2	0.0010	ND	ND
TRI-17	WS1-2	10/21 - 10/22/98	Stream at Wallace Home - sampler 1	0.0010	ND	ND
TRI-18	WS2-2	10/21 - 10/22/98	Stream at Wallace Home - sampler 2	0.0009	ND	ND
TRI-33	WS1-3	10/22 - 10/23/98	Stream at Wallace Home - sampler 1	0.0010	ND	ND
TRI-34	WS2-3	10/22 - 10/23/98	Stream at Wallace Home - sampler 2	0.0010	ND	ND
TRI-3	WSN-1	10/20 - 10/21/98	Stream at Wallace Home - sampler facing north	0.0004	0.0004	ND
TRI-4	WSS-1	10/20 - 10/21/98	Stream at Wallace Home - sampler facing south	0.0032	0.0032	ND
TRI-19	WSN-2	10/21 - 10/22/98	Stream at Wallace Home - sampler facing north	0.0004	ND	ND
TRI-20	WSS-2	10/21 - 10/22/98	Stream at Wallace Home - sampler facing south	0.0016	ND	ND
TRI-35	WSN-3	10/22 - 10/23/98	Stream at Wallace Home - sampler facing north	0.0005	ND	ND
TRI-36	WSS-3	10/22 - 10/23/98	Stream at Wallace Home - sampler facing south	0.0021	0.0232	ND
TRI-49	BUDS-2	10/22 - 10/23/98	box blank	0.0010	ND	ND
TRI-50	BUDS-1	10/22 - 10/23/98	field blank	0.0010	ND	ND

ATTACHMENT 3
Meteorological Data

WIND ROSE PLOT

STATION #60000 - , Met Station On Telephone Pole Next to Trailer





MODELER

DATE
3/29/99

COMPANY NAME

DISPLAY
Wind Speed

UNIT
Knots

COMMENTS
Third Day of Sampling
October 22-23, 1998
Start Time 0900 hrs

AVG. WIND SPEED
1.00 Knots

CALM WINDS
91.67%

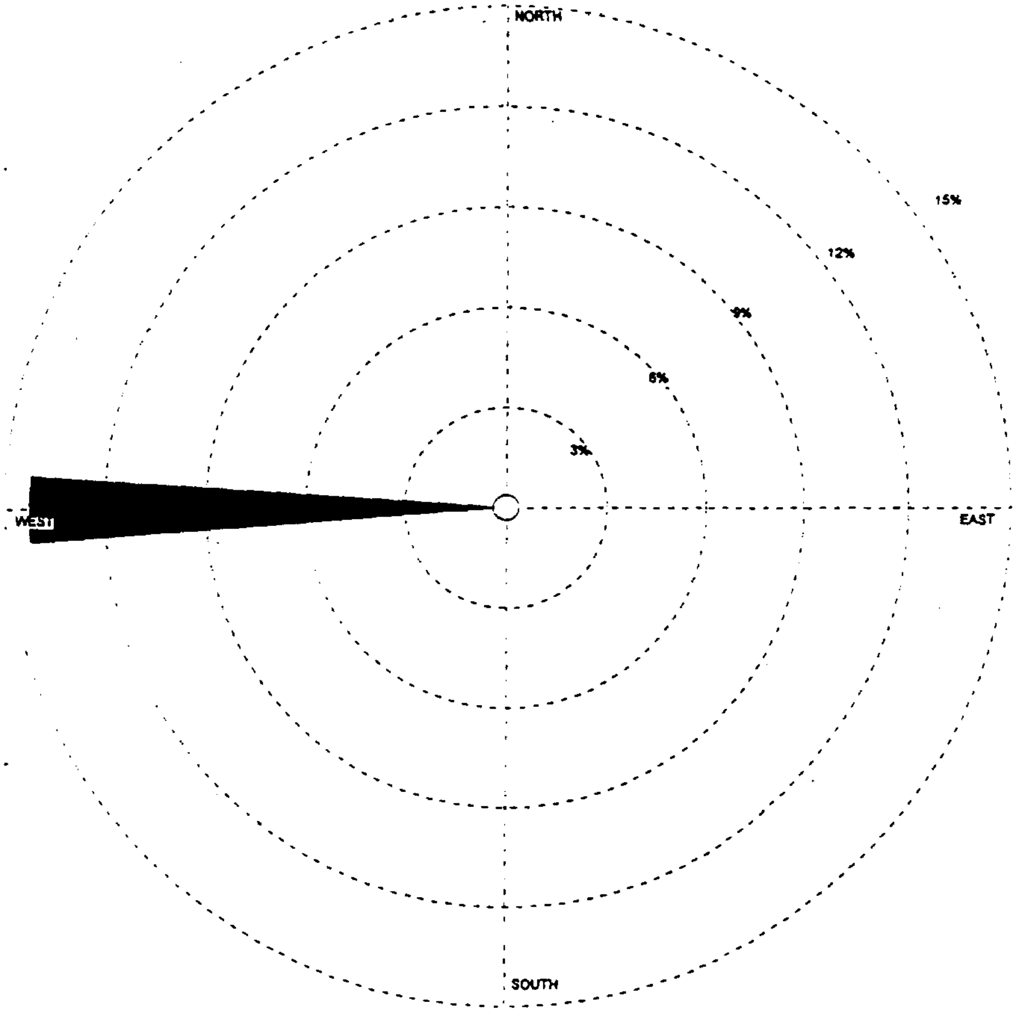
ORIENTATION
Direction
(blowing from)

PLOT YEAR-DATE-TIME
98
October 22 - October 23
Midnight - 11 PM

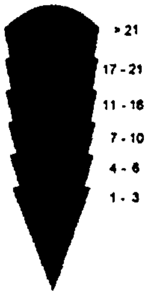
PROJECT/PLOT NO.
C-98-063

WIND ROSE PLOT

STATION #60000 - , Met Station On Telephone Pole Next to Trailer



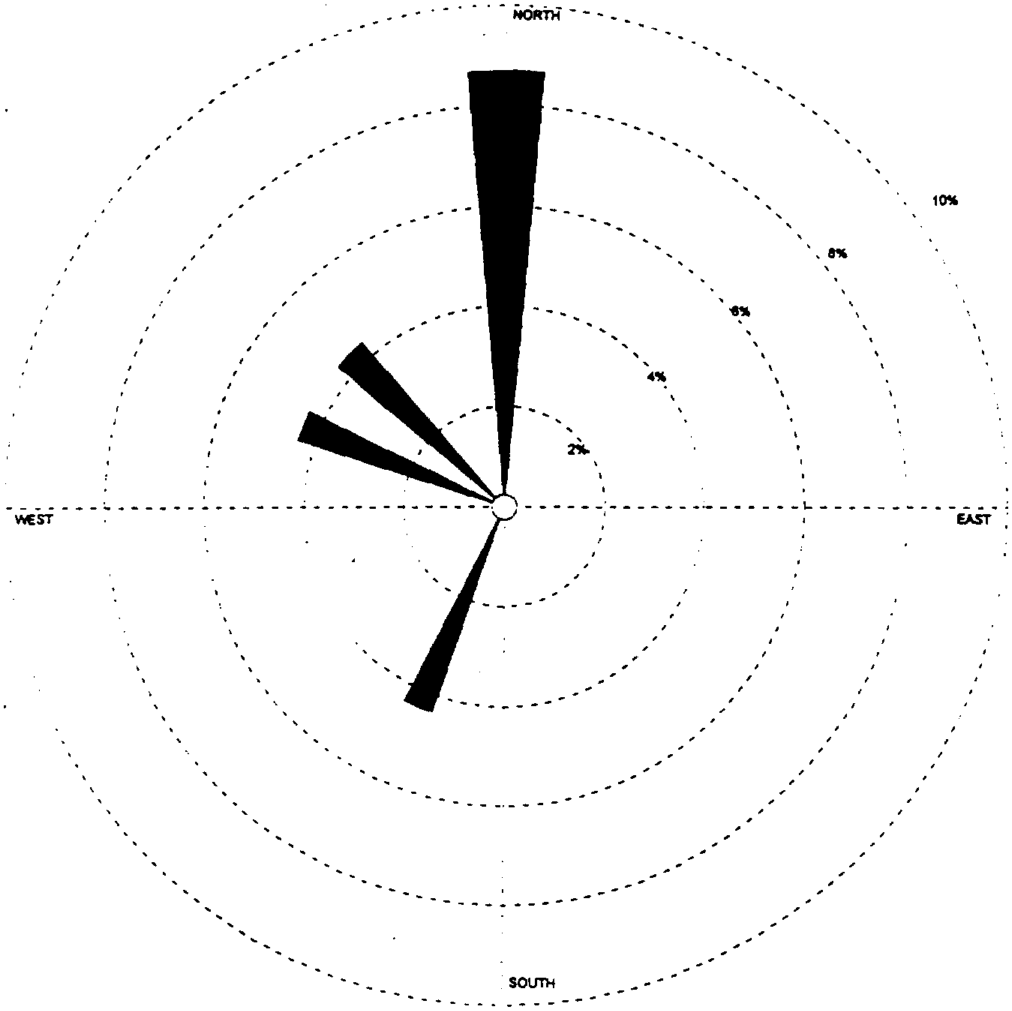
Wind Speed (Knots)



MODELER	DATE 3/29/99	COMPANY NAME
DISPLAY Wind Speed	UNIT Knots	COMMENTS Second Day of Sampling October 21-22, 1998 Start Time 0900 hrs
AVG. WIND SPEED 1.00 Knots	CALM WINDS 85.71%	
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 98 October 21 - October 22 Midnight - 11 PM	PROJECT/PLOT NO C-98-063

WIND ROSE PLOT

STATION #60000 - , Met Station On Telephone Pole Next to Trailer

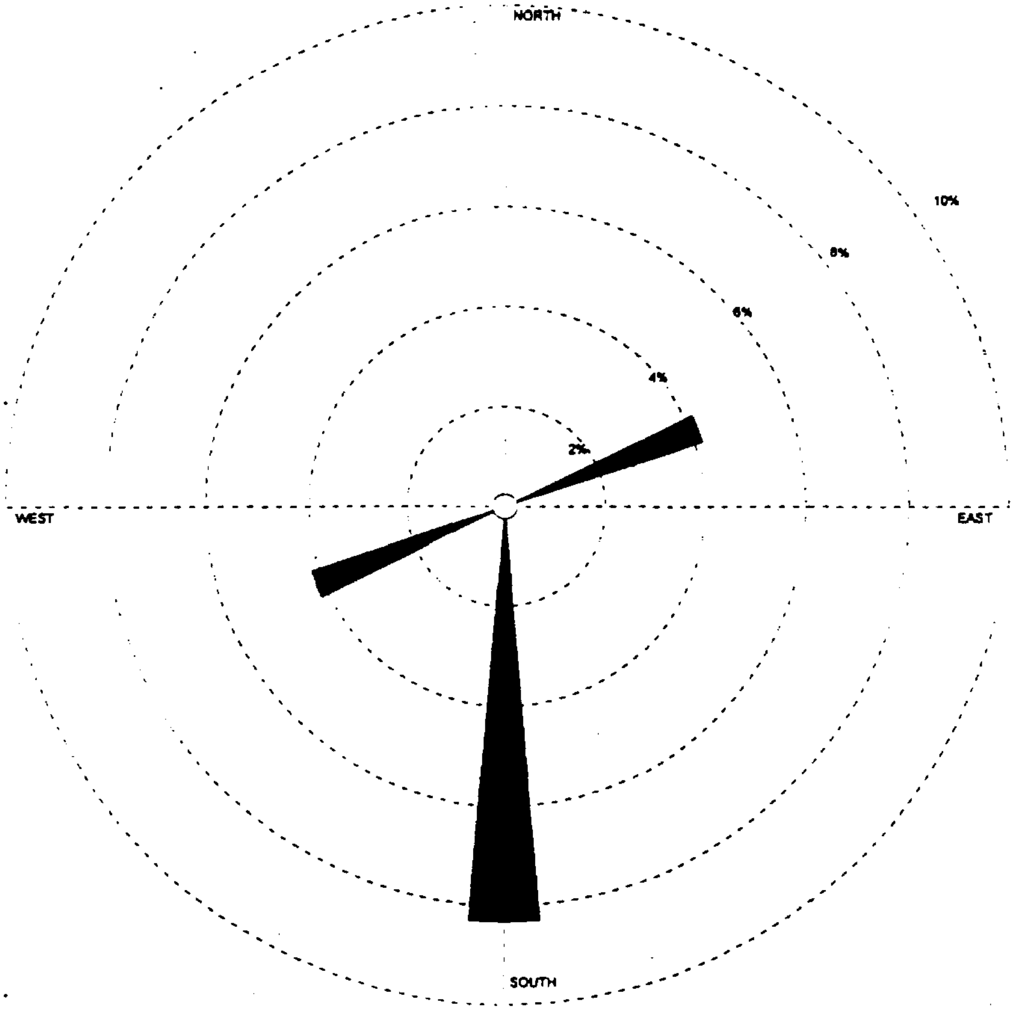


Wind Speed (Knots)

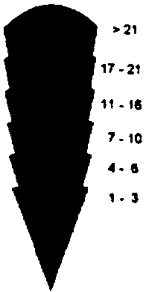
MODELER	DATE 3/29/99	COMPANY NAME
DISPLAY Wind Speed	UNIT Knots	COMMENTS First Day of Sampling October 20-21, 1998 Start Time 0900 hrs
AVG. WIND SPEED 1.80 Knots	CALM WINDS 78.26%	
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 98 October 20 - October 21 Midnight - 11 PM	PROJECT/PLOT NO. C-98-063

WIND ROSE PLOT

STATION #60000 - , Met Station Next to Stream across from North Entrance to Quarry



Wind Speed (Knots)

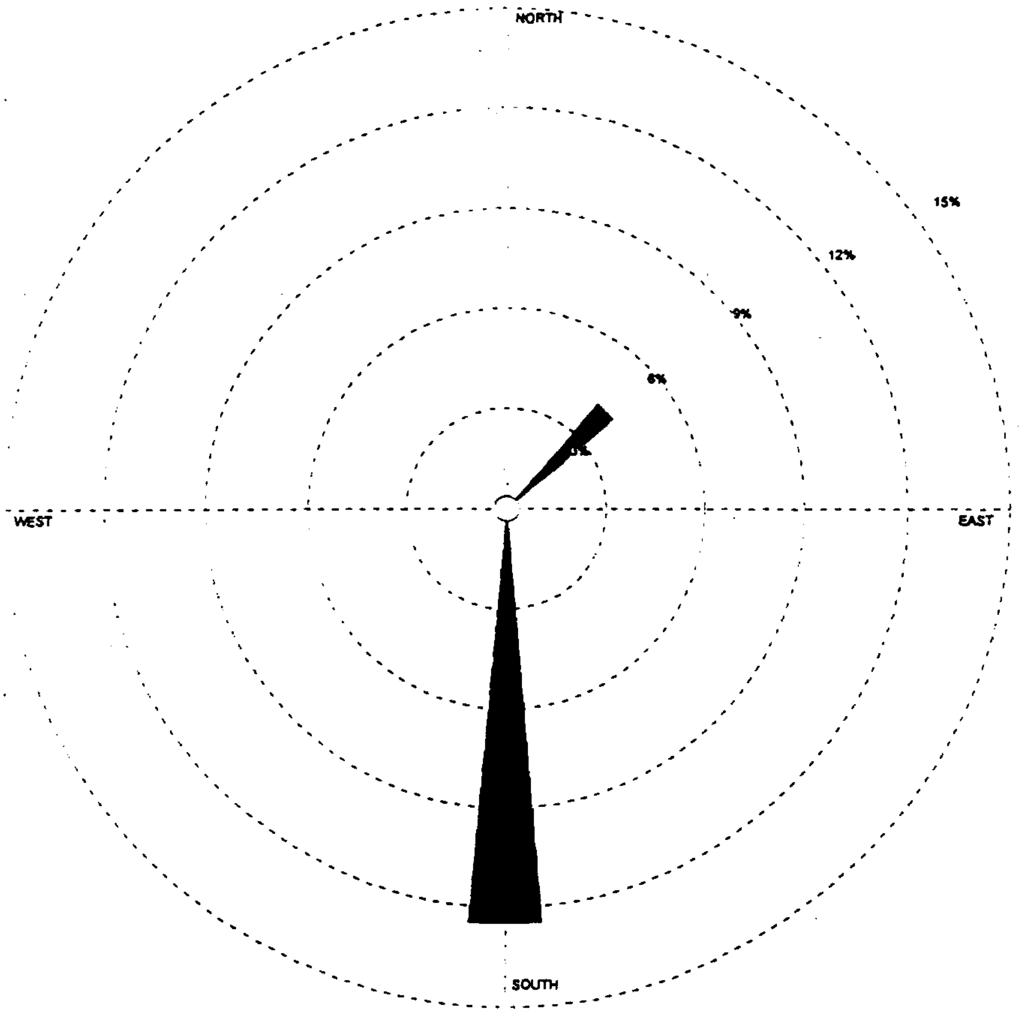


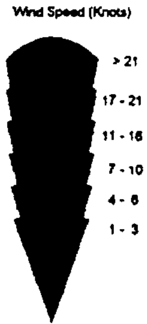
MODELER	DATE 3/29/99	COMPANY NAME
DISPLAY Wind Speed	UNIT Knots	COMMENTS Third Day of Sampling October 22-23, 1998 Start Time 0900 hrs
AVG. WIND SPEED 1.25 Knots	CALM WINDS 83.33%	
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 98 October 22 - October 23 Midnight - 11 PM	PROJECT/PLOT NO. C-98-063

[illegible]

WIND ROSE PLOT

STATION #60000 - , Met Station Next to Stream across from North Entrance to Quarry

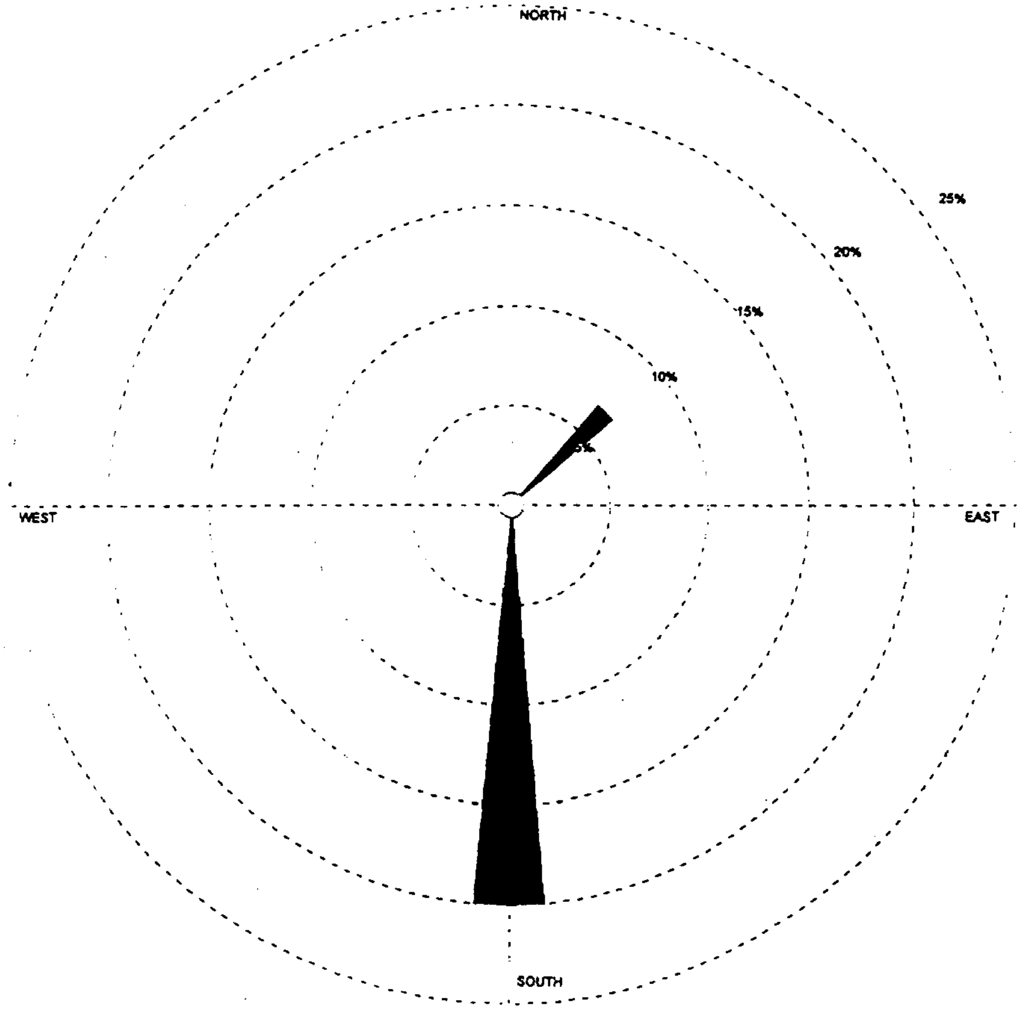




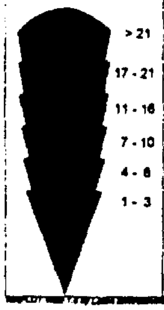
MODELER	DATE 3/29/99	COMPANY NAME
DISPLAY Wind Speed	UNIT Knots	COMMENTS Second Day of Sampling October 21-22, 1998 Start Time 0900 hrs
AVG. WIND SPEED 1.00 Knots	CALM WINDS 83.33%	
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 98 October 21 - October 22 Midnight - 11 PM	PROJECT/PLOT NO. C-98-063

WIND ROSE PLOT

STATION #60000 - , Met Station Next to Stream across from North Entrance to Quarry



Wind Speed (Knots)



MODELER

DATE
3/29/99

COMPANY NAME

DISPLAY
Wind Speed

UNIT
Knots

COMMENTS
First Day of Sampling
October 20-21, 1998
Start Time 0900 hrs

AVG. WIND SPEED
1.00 Knots

CALM WINDS
73.33%

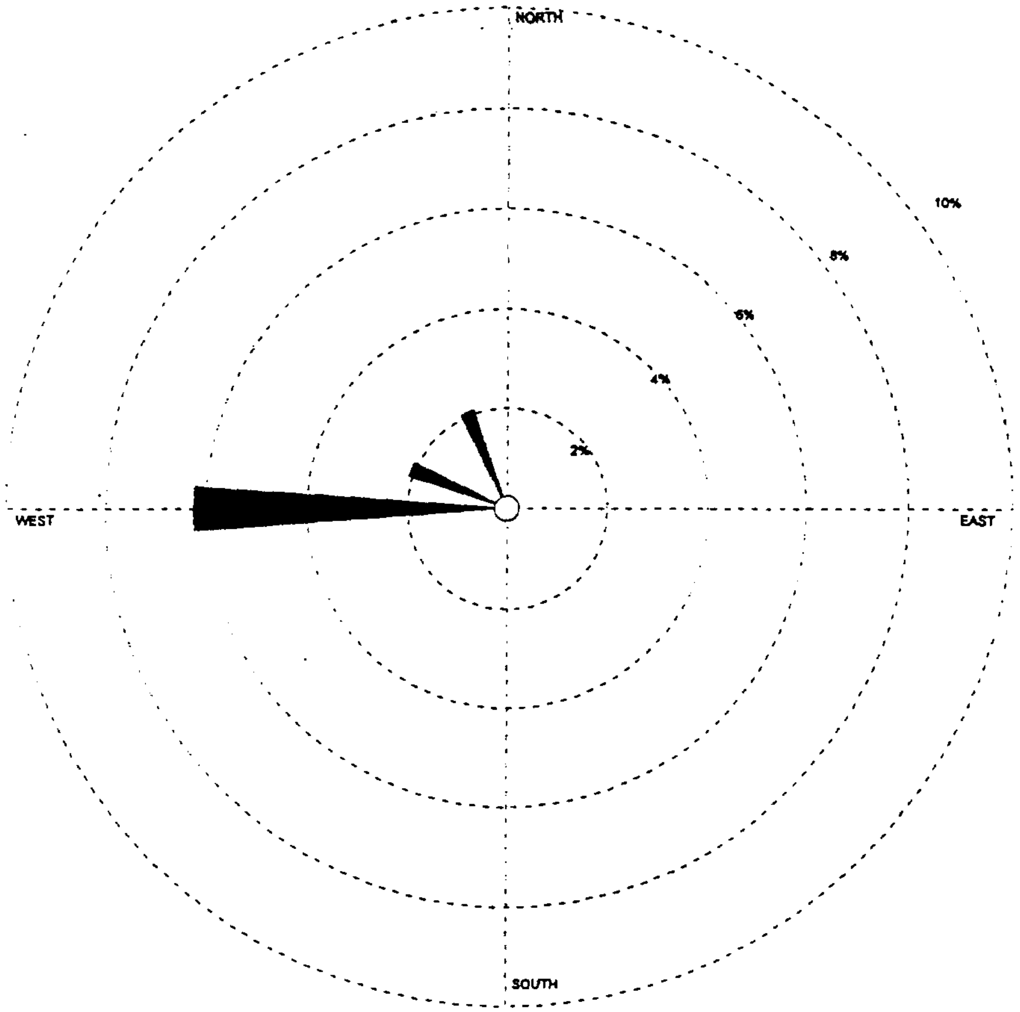
ORIENTATION
Direction
(blowing from)

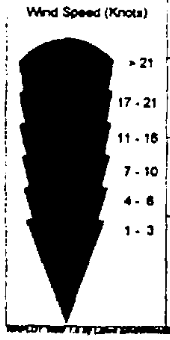
PLOT YEAR-DATE-TIME
98
October 20 - October 21
Midnight - 11 PM

PROJECT/PLOT NO.
C-98-063

WIND ROSE PLOT

STATION #40000 - , Met Station on Roof of Concession Stand in Caltrans Rest Area

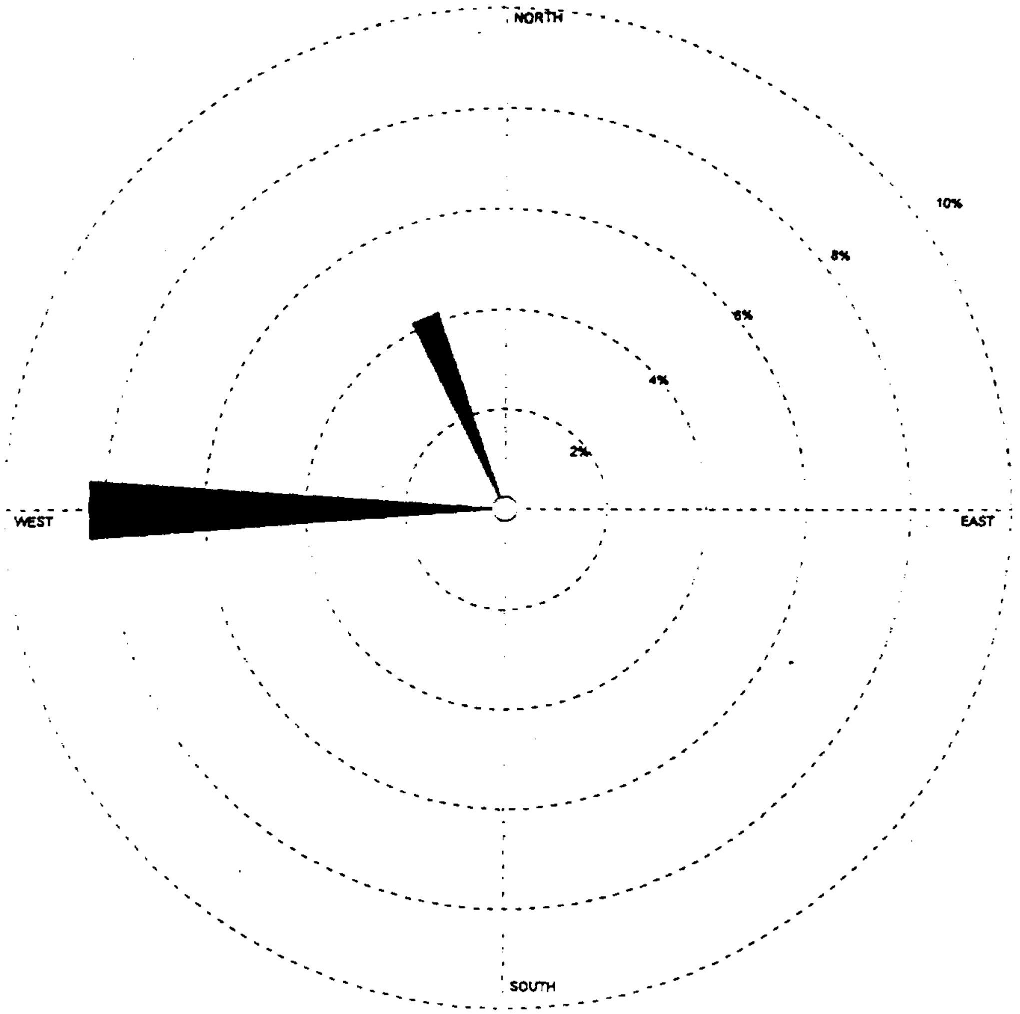




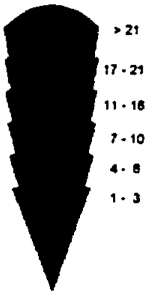
MODELER	DATE 3/29/99	COMPANY NAME
DISPLAY Wind Speed	UNIT Knots	COMMENTS Third Day of Sampling October 22-23, 1998 Start Time 1100 hrs
AVG. WIND SPEED 1.20 Knots	CALM WINDS 89.58%	
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 98 October 22 - October 23 Midnight - 11 PM	PROJECT/PLOT NO C-98-063

WIND ROSE PLOT

STATION #40000 - , Met Station on Roof of Concession Stand in Caltrans Rest Area



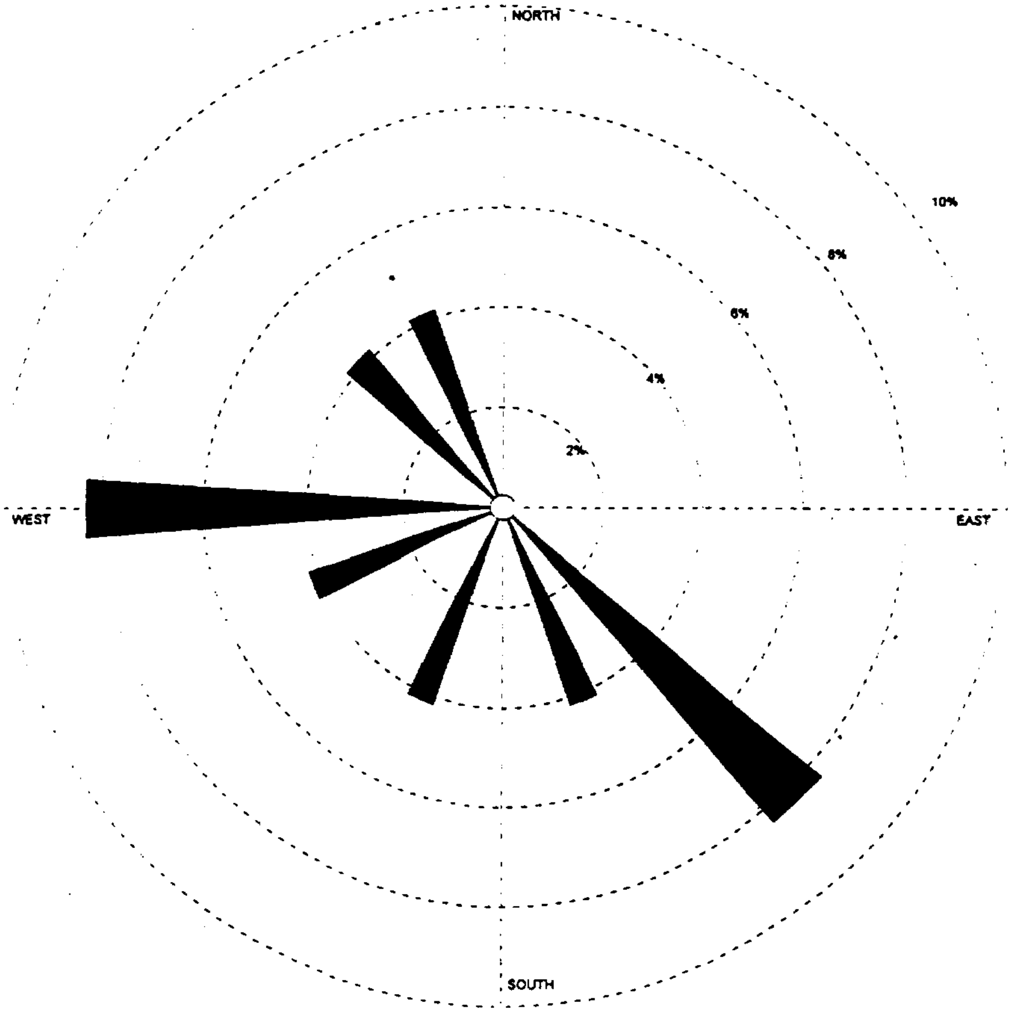
Wind Speed (Knots)

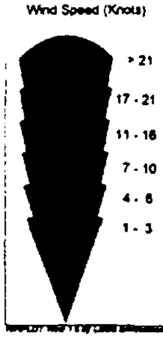


MODELER	DATE 3/29/99	COMPANY NAME
DISPLAY Wind Speed	UNIT Knots	COMMENTS Second Day of Sampling October 21-22, 1998 Start Time 1100 hrs
AVG. WIND SPEED 2.00 Knots	CALM WINDS 87.50%	
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 98 October 21 - October 22 Midnight - 11 PM	PROJECT/PLOT NO. C-98-063

WIND ROSE PLOT

STATION #40000 - , Met Station on Roof of Concession Stand in Caltrans Rest Area





MODELER

DATE
3/29/99

COMPANY NAME

DISPLAY
Wind Speed

UNIT
Knots

COMMENTS
First Day of Sampling
October 20-21, 1998
Start Time 1100 hrs

AVG. WIND SPEED
1.67 Knots

CALM WINDS
62.50%

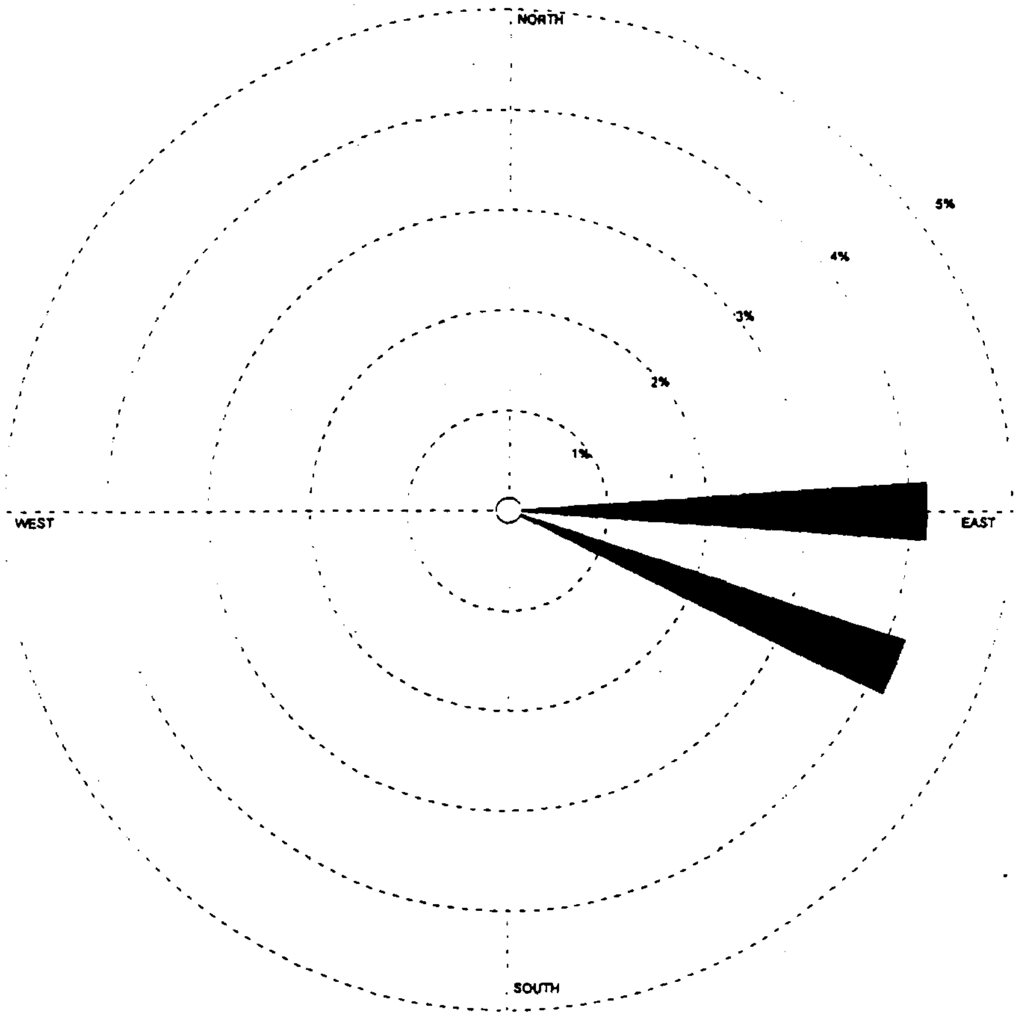
ORIENTATION
Direction
(blowing from)

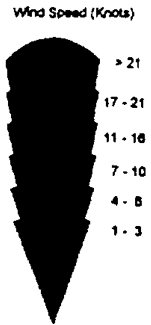
PLOT YEAR-DATE-TIME
98
October 20 - October 21
Midnight - 11 PM

PROJECT/PLOT NO
C-98-063

WIND ROSE PLOT

STATION #30000 - , Met Station on Ground Next to House

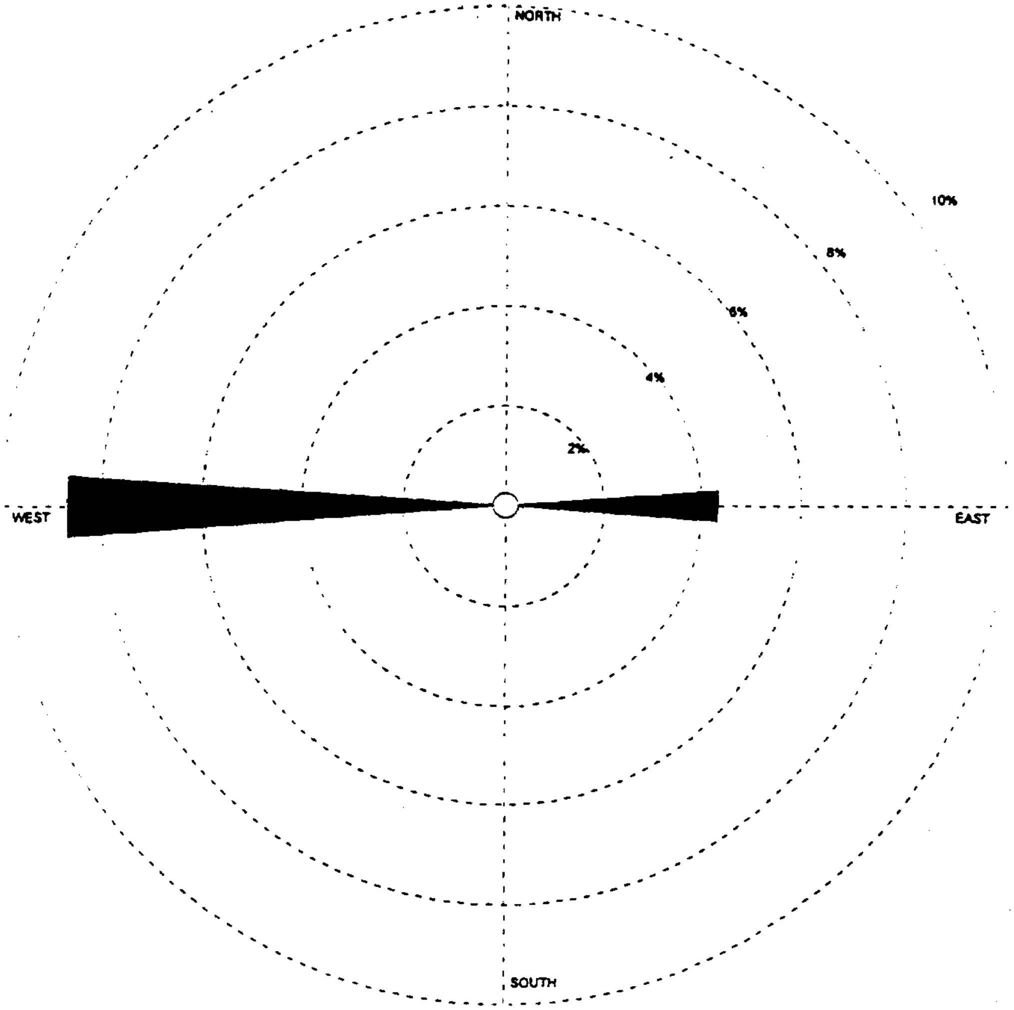




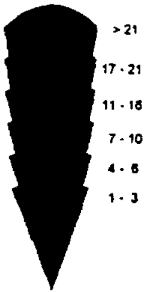
MODELER	DATE 3/29/99	COMPANY NAME
DISPLAY Wind Speed	UNIT Knots	COMMENTS Second Day of Sampling October 21-22, 1998 Start Time 0900 hrs
AVG. WIND SPEED 1.00 Knots	CALM WINDS 91.87%	
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 98 October 21 - October 22 Midnight - 11 PM	PROJECT/PLOT NO C-98-063

WIND ROSE PLOT

STATION #30000 - , Met Station on Ground Next to House



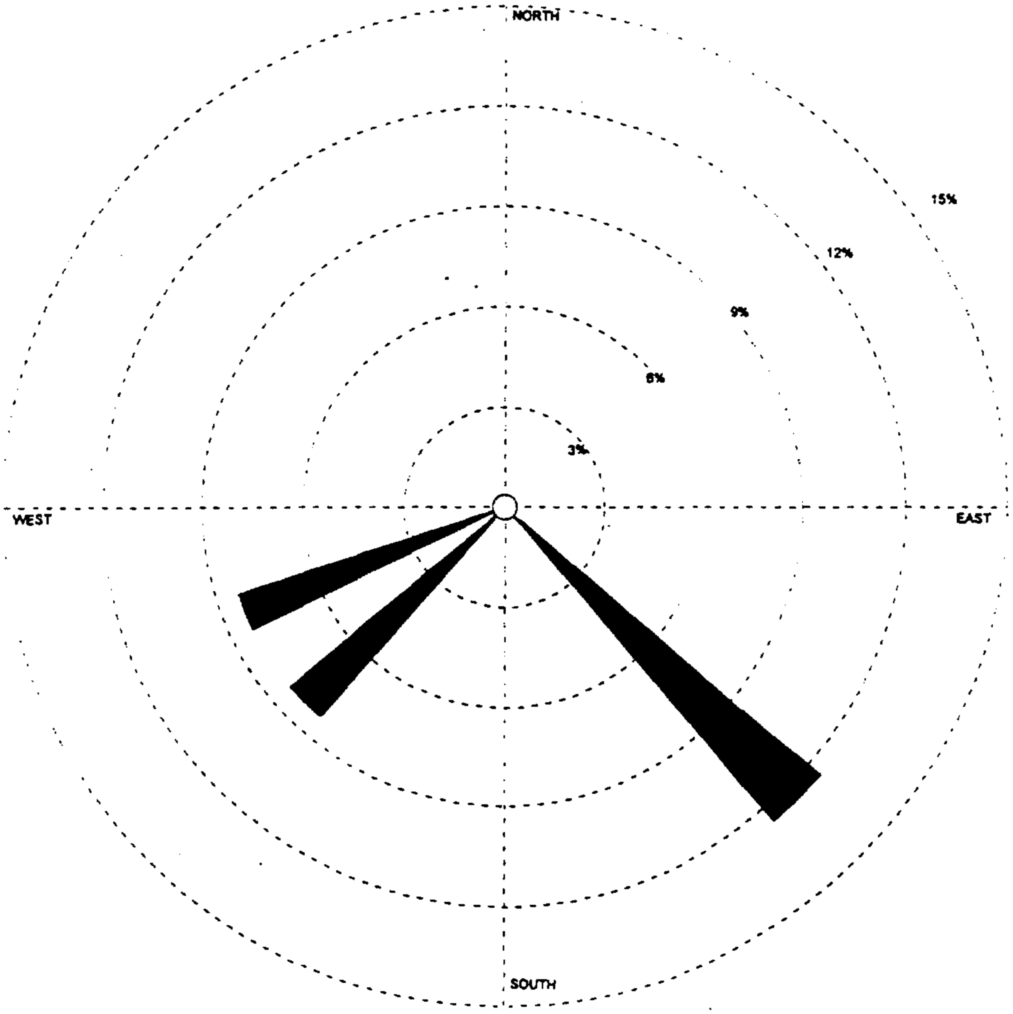
Wind Speed (Knots)



MODELER	DATE 3/29/99	COMPANY NAME
DISPLAY **Wind Speed**	UNIT **Knots**	COMMENTS **First Day of Sampling** **October 20-21, 1998** **Start Time 0900 hrs**
AVG. WIND SPEED 1.00 Knots	CALM WINDS **88.96%**	
ORIENTATION **Direction** **(blowing from)**	PLOT YEAR-DATE-TIME **98** **October 20 - October 21** **Midnight - 11 PM**	PROJECT/PLOT NO. **C-98-063**

WIND ROSE PLOT

STATION #20000 - , Met Station on Roof of Fire Station in Douglas City



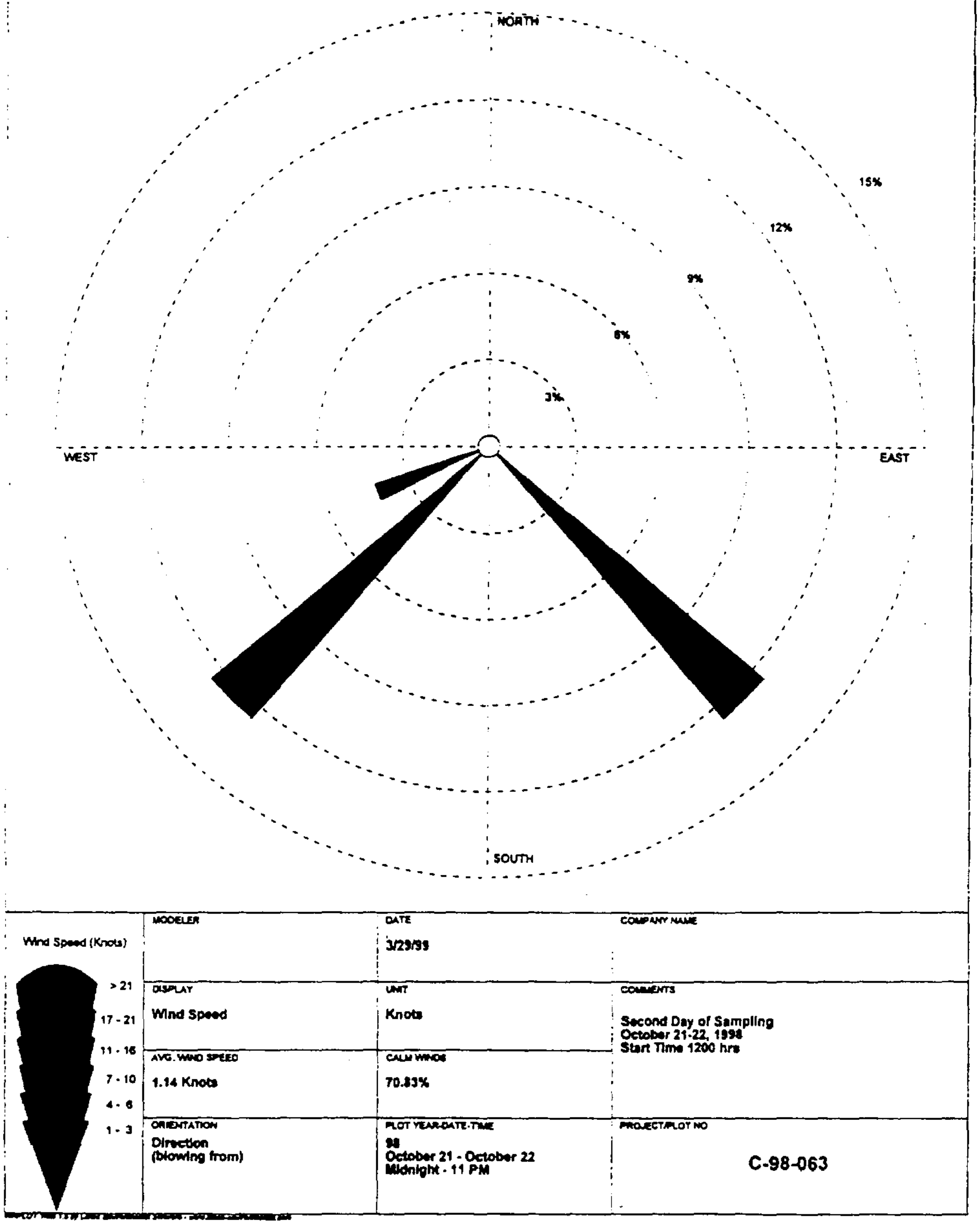
Wind Speed (Knots)

> 21
17 - 21
11 - 16
7 - 10
4 - 6
1 - 3

MODELER	DATE 3/29/99	COMPANY NAME
DISPLAY Wind Speed	UNIT Knots	COMMENTS Third Day of Sampling October 22-23, 1998 Start Time 1200 hrs
AVG. WIND SPEED 1.71 Knots	CALM WINDS 70.83%	
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 98 October 22 - October 23 Midnight - 11 PM	PROJECT/PLOT NO. C-98-063

WIND ROSE PLOT

STATION #20000 - Met Station on Roof of Fire Station in Douglas City, CA



MODELER

DATE
3/29/99

COMPANY NAME

DISPLAY
Wind Speed

UNIT
Knots

COMMENTS
Second Day of Sampling
October 21-22, 1998
Start Time 1200 hrs

AVG. WIND SPEED
1.14 Knots

CALM WINDS
70.83%

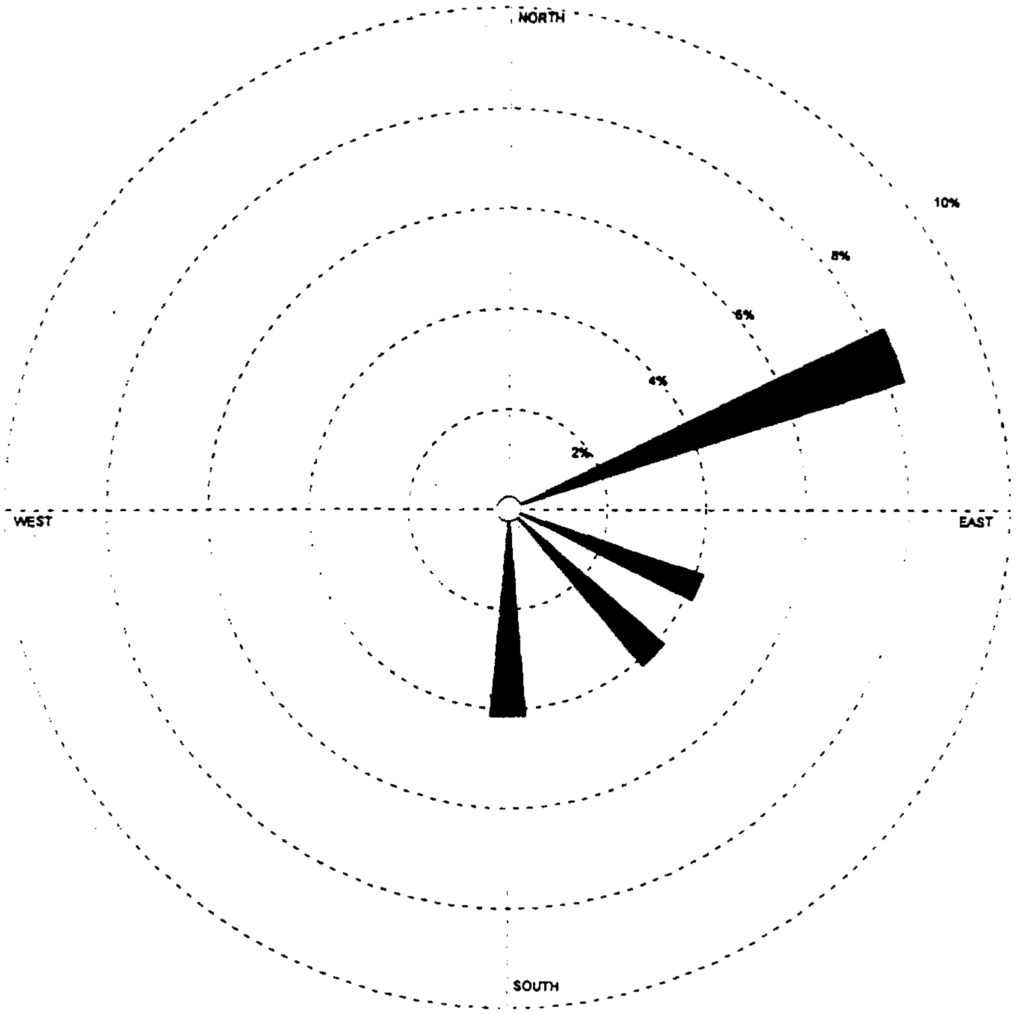
ORIENTATION
Direction
(blowing from)

PLOT YEAR-DATE-TIME
98
October 21 - October 22
Midnight - 11 PM

PROJECT/PLOT NO
C-98-063

WIND ROSE PLOT

STATION #10000 - , Met Station on Roof of Courthouse, Weaverville, CA

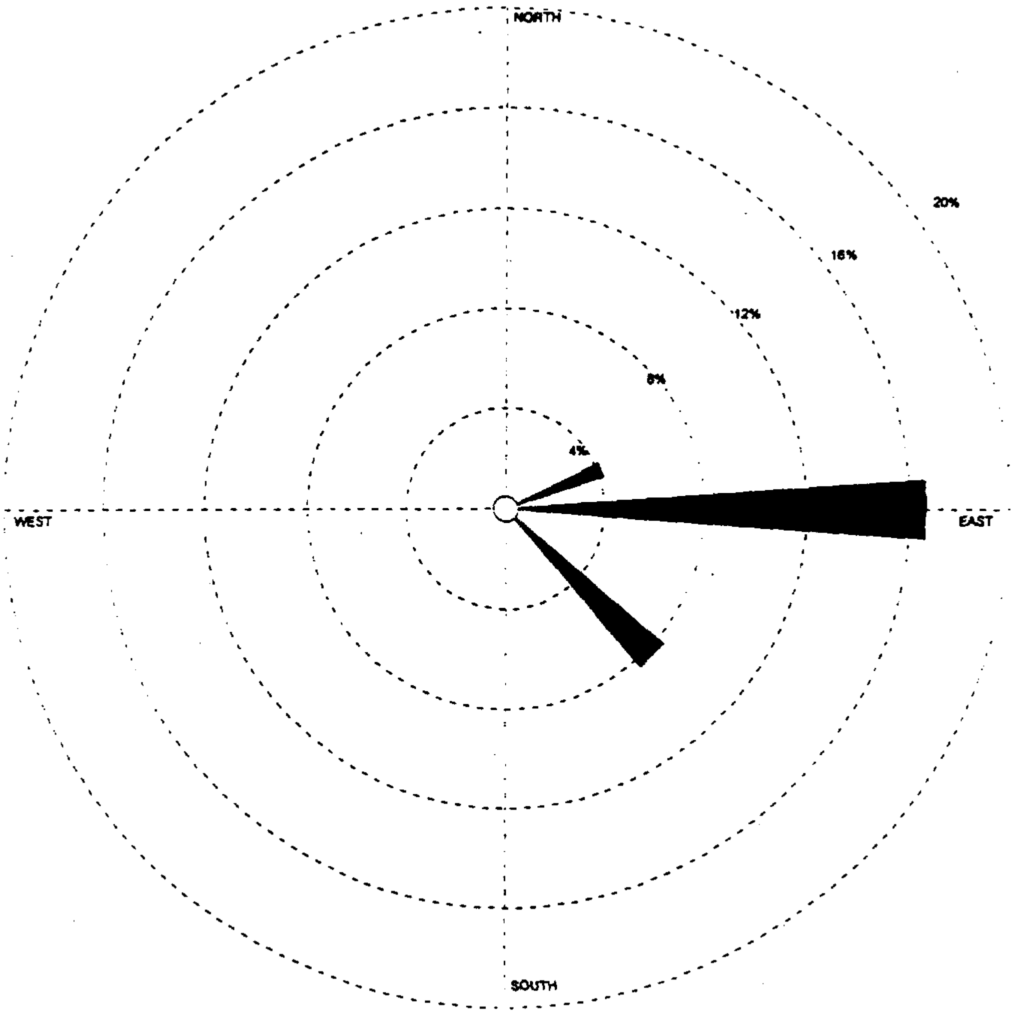


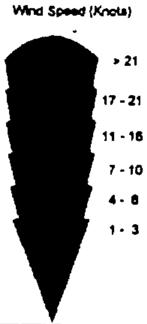
Wind Speed (Knots)

MODELER	DATE 3/29/99	COMPANY NAME
DISPLAY Wind Speed	UNIT Knots	COMMENTS Third Day of Sampling October 22-23, 1998 Start Time 1300 hrs
AVG. WIND SPEED 1.40 Knots	CALM WINDS 79.17%	
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 98 October 22 - October 23 Midnight - 11 PM	PROJECT/PLOT NO. C-98-063

WIND ROSE PLOT

STATION #20000 - , Met Station on Roof of Fire Station in Douglas City





MODELER

DATE
3/29/99

COMPANY NAME

DISPLAY
Wind Speed

UNIT
Knots

COMMENTS
First Day of Sampling
October 20-21, 1998
Start Time 1200 hrs

AVG. WIND SPEED
2.14 Knots

CALM WINDS
70.83%

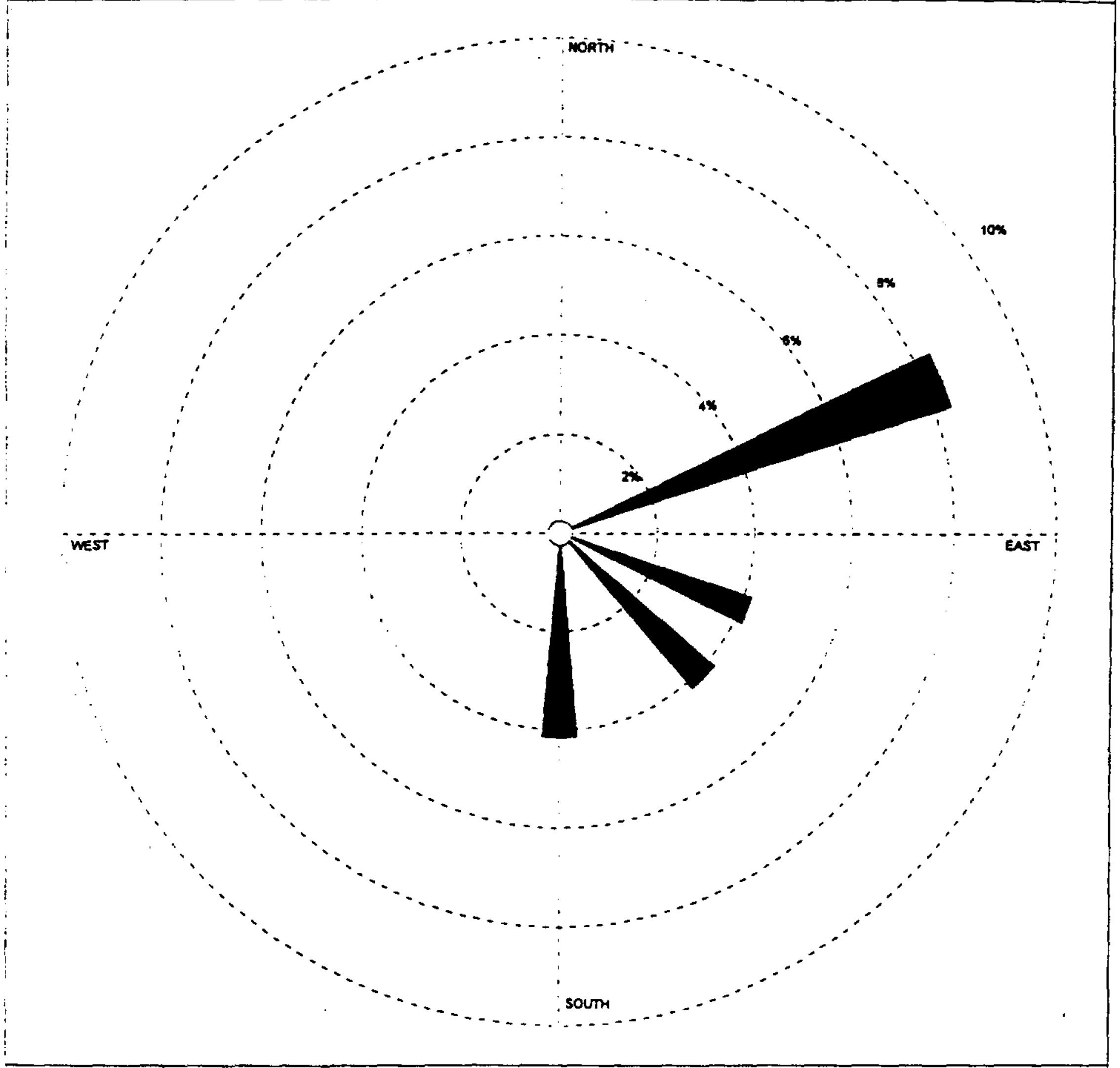
ORIENTATION
Direction
(blowing from)

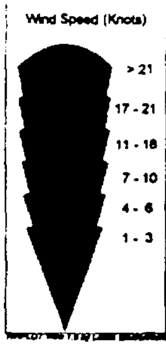
PLOT YEAR-DATE-TIME
98
October 20 - October 21
Midnight - 11 PM

PROJECT/PLOT NO.
C-98-063

WIND ROSE PLOT

STATION #10000 - , Met Station on Roof of Courthouse, Weaverville, CA





MODELER

DATE
3/29/99

COMPANY NAME

DISPLAY
Wind Speed

UNIT
Knots

COMMENTS
Third Day of Sampling
October 22-23, 1998
Start Time 1300 hrs

AVG. WIND SPEED
1.40 Knots

CALM WINDS
79.17%

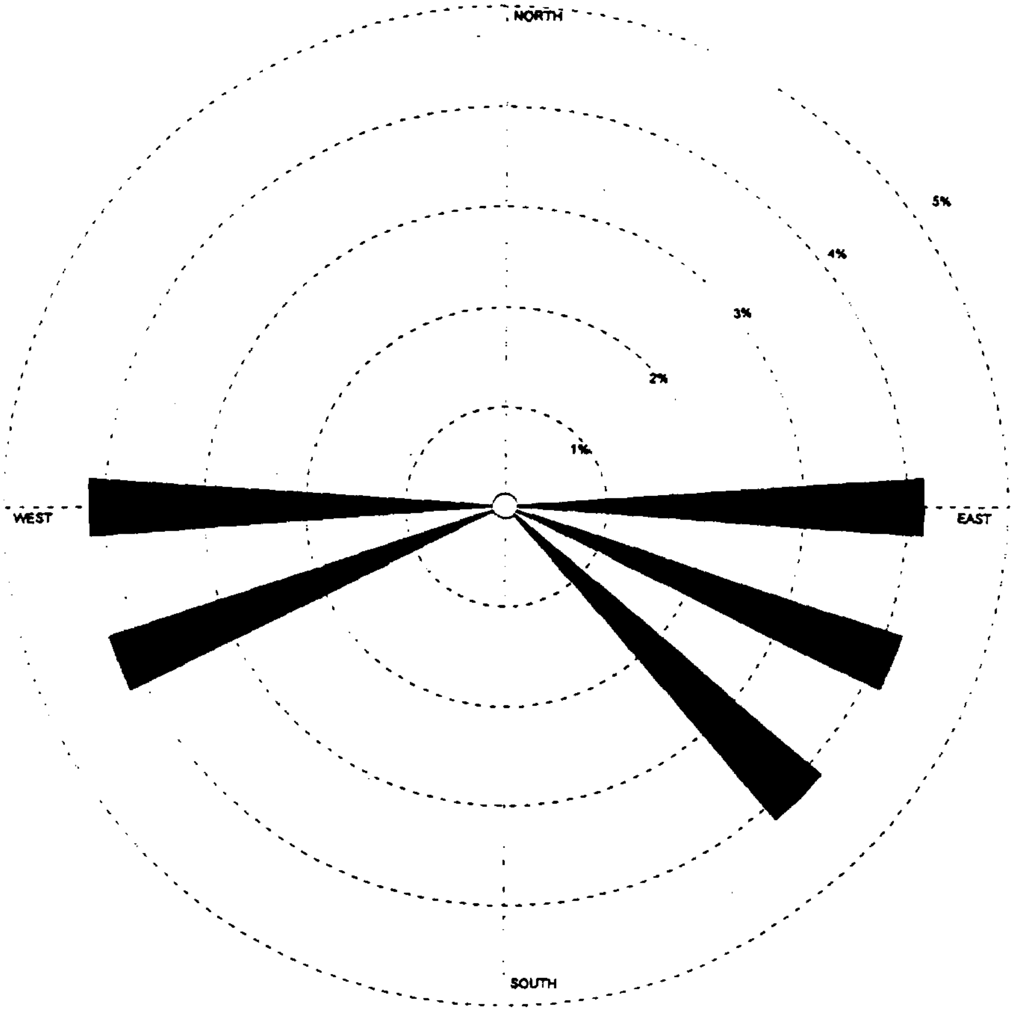
ORIENTATION
Direction
(blowing from)

PLOT YEAR-DATE-TIME
98
October 22 - October 23
Midnight - 11 PM

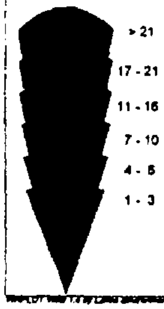
PROJECT/PLOT NO.
C-98-063

WIND ROSE PLOT

STATION #10000 - , Met Station on Roof of Courthouse, Weaverville, CA



Wind Speed (Knots)



MODELER

DATE
3/23/99

COMPANY NAME

DISPLAY
Wind Speed

UNIT
Knots

COMMENTS
Second Day of Sampling
October 21-22, 1998
Start Time 1300hrs

AVG. WIND SPEED
1.00 Knots

CALM WINDS
79.17%

ORIENTATION
Direction
(blowing from)

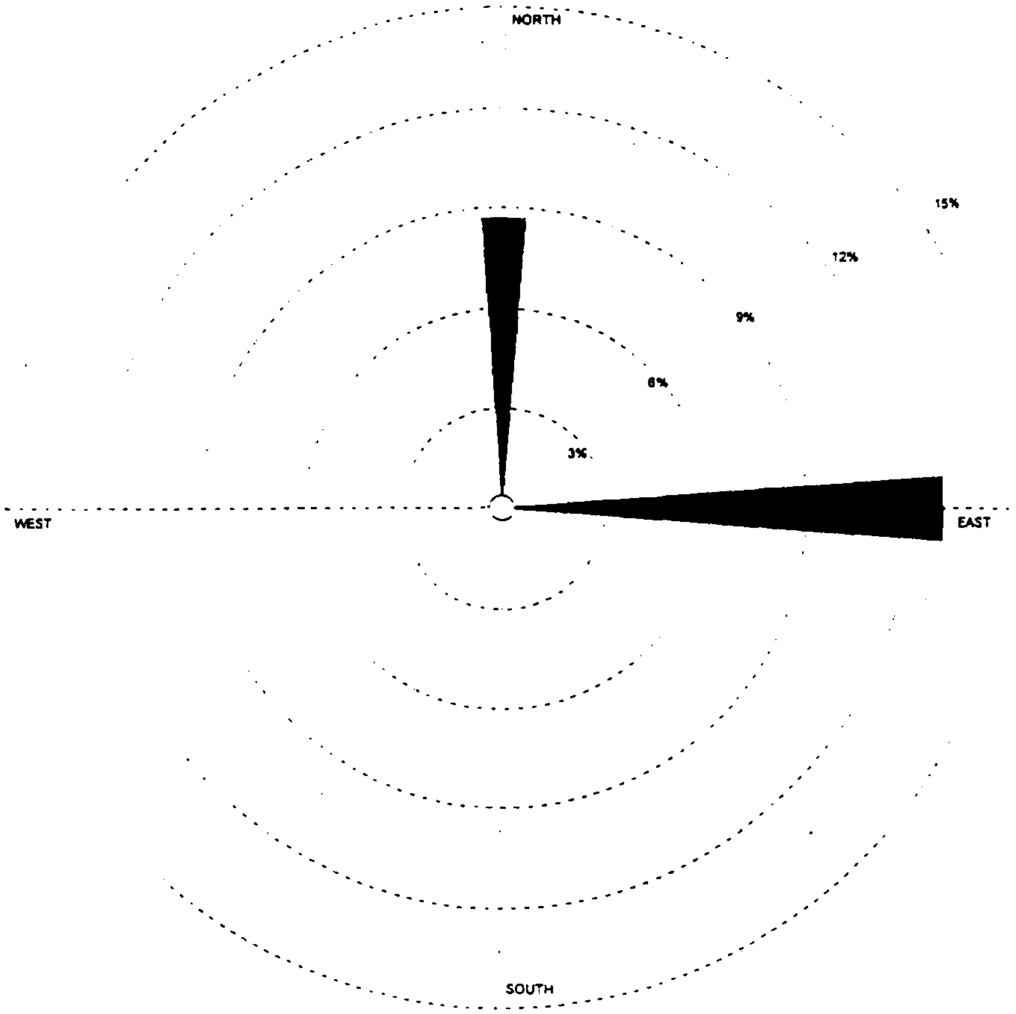
PLOT YEAR-DATE-TIME
98
October 21 - October 22
Midnight - 11 PM

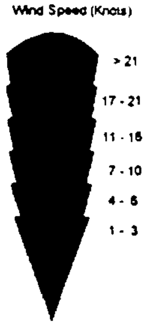
PROJECT/PLOT NO.
C-98-063

[illegible]

WIND ROSE PLOT

STATION #10000 - , Met Station on Roof of Courthouse, Weaverville, CA

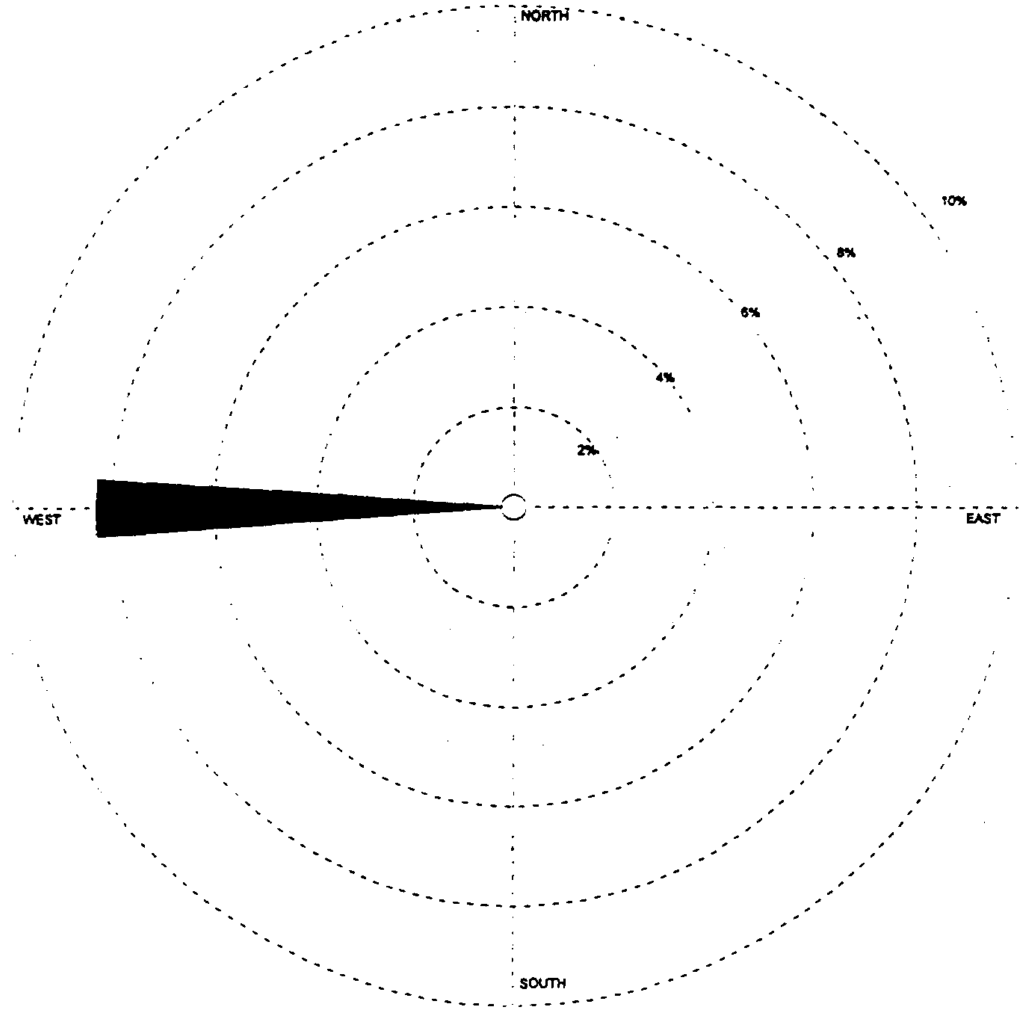




MODELER	DATE 3/29/99	COMPANY NAME
DISPLAY Wind Speed	UNIT Knots	COMMENTS First Day of Sampling October 20 -21, 1998 Start Time 1300hrs
AVG. WIND SPEED 2.60 Knots	CALM WINDS 78.26%	
ORIENTATION Direction (blowing from)	PLOT YEAR-DATE-TIME 98 October 20 - October 21	PROJECT/PLOT NO. C-98-063

WIND ROSE PLOT

STATION #60000 - , Met Station On Telephone Pole Next to Trailer



Wind Speed (Knots)

MODELER

DATE
3/29/99

COMPANY NAME

DISPLAY
Wind Speed

UNIT
Knots

COMMENTS
Third Day of Sampling
October 22-23, 1998
Start Time 0900 hrs

AVG. WIND SPEED
1.00 Knots

CALM WINDS
91.67%

ORIENTATION
Direction
(blowing from)

PLOT YEAR-DATE-TIME
98
October 22 - October 23
Midnight - 11 PM

PROJECT/PLOT NO.
C-98-063

ATTACHMENT 4
RJ Lee Results

RJ Lee *Group*, Inc.

530 McCormick St. • San Leandro, CA 94577
(510) 567-0480 • FAX (510) 567-0488

March 10, 1999

Mr. George Lew
California Air Resources Board
Engineering & Laboratory Branch
600 North Market Blvd
Sacramento, CA 95834

RE: TEM Asbestos Analysis Results for Samples as Shown on Test Report & Table II
RJ Lee Group Job No.: ATC902247
Customer Project No.: C-98-063

Dear Mr. Lew:

Enclosed are the results from the transmission electron microscopy (TEM) asbestos analysis for your above referenced project using CARB Level III analysis. Test Report lists each sample identification number, filter area, sample volume, area analyzed, structure counts, analytical sensitivity, and the concentration of asbestos. Table II lists the same information as Test Report for structures ≥ 5μm in length. Table V lists the 95% confidence limits for the analyses, based on the Poisson distribution. Count sheets are included.

These results are submitted pursuant to RJ Lee Group's current terms and conditions of sale, including the commpany's standard warranty and limitation of liability provisions and no responsibility or liability is assumed for the manner in which the results are used or interpreted.

Should you have any questions, please feel free to call.

Sincerely,

Bernard Thomas
Project Manager

BT/sjb
Enclosures

Monroeville, PA • San Leandro, CA • Washington, D.C. • Houston, TX
Chopra-Lee, Inc., Grand Island, NY

Test Report

Total Asbestos Structure Concentration

TEM Level III Analysis

Project ATC902247

RJ Lee Group Sample Number	Client Sample Number	Filter Area (sq mm)	Volume ‡ (Liters)	Area Analyzed (sq mm)	Structures		Analytical Sensitivity †		Concentration		Analysis Date
					Chr	Amp	(S/sq. mm)	(S/cc)	(S/sq. mm)	(S/cc)	
1821537CT	TRI-1-WS1-1	385	4441.00	0.0921	3	0	10.9	0.0009	32.6	0.0028	3/9/99
1821538CT	TRI-2-WS2-1	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821539CT	TRI-3-WSN-1	385	11610.00	0.0921	1	0	10.9	0.0004	10.9	0.0004	3/9/99
1821540CT	TRI-4-WSS-1	385	1313.00	0.0921	1	0	10.9	0.0032	10.9	0.0032	3/9/99
1821541CT	TRI-5-WH1-1	385	4309.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821542CT	TRI-6-WH2-1	385	4307.00	0.0921	1	0	10.9	0.0010	10.9	0.0010	3/9/99
1821543CT	TRI-7-TLR1-1	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821544CT	TRI-8-TLR2-1	385	4217.00	0.0921	9	0	10.9	0.0010	97.8	0.0089	3/9/99
1821545CT	TRI-9-RA1-1	385	4189.00	0.0921	5	0	10.9	0.0010	54.3	0.0050	3/9/99
1821546CT	TRI-10-RA2-1	385	4282.00	0.0921	3	0	10.9	0.0010	32.6	0.0029	3/9/99
1821547CT	TRI-11-RAN-1	385	6890.00	0.0921	2	0	10.9	0.0006	21.7	0.0012	3/9/99
1821548CT	TRI-12-RAS-1	385	6948.00	0.0921	1	0	10.9	0.0006	10.9	0.0006	3/9/99
1821549CT	TRI-13-FS1-1	385	4320.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821550CT	TRI-14-FS2-1	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821551CT	TRI-15-CH1-1	385	4297.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821552CT	TRI-16-CH2-1	385	1922.00	0.0921	0	0	10.9	0.0022	<10.9*	<0.0022*	3/9/99

‡ Volumes provided by California Air Resources Board for Project C-98-063 were used to calculate analytical results and sensitivities.

†Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.

Chr - Chrysotile, Amp - Amphibole
Samples received on: Wednesday, February 24, 1999
* Results Less Than Analytical Sensitivity.
N/A - Sample not analyzed.

Authorized Signature
Bernard Thomas, Project Manager

Date

Test Report

Total Asbestos Structure Concentration
TEM Level III Analysis
Project ATC902247

RJ Lee Group Sample Number	Client Sample Number	Filter Area (sq mm)	Volume ‡ (Liters)	Area Analyzed (sq mm)	Structures		Analytical Sensitivity †		Concentration		Analysis Date
					Chr	Amp	(S/sq. mm)	(S/cc)	(S/sq. mm)	(S/cc)	
1821553CT	TRI-17-WS1-2	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821554CT	TRI-18-WS2-2	385	4444.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	3/9/99
1821555CT	TRI-19-WSN-2	385	9741.00	0.0921	0	0	10.9	0.0004	<10.9*	<0.0004*	3/9/99
1821556CT	TRI-20-WSS-2	385	2655.00	0.0921	0	0	10.9	0.0016	<10.9*	<0.0016*	3/9/99
1821557CT	TRI-21-WH1-2	385	4462.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	3/9/99
1821558CT	TRI-22-WH2-2	385	4462.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	3/9/99
1821559CT	TRI-23-TLR1-2	385	4275.00	0.0921	8	0	10.9	0.0010	86.9	0.0078	3/9/99
1821560CT	TRI-24-TLR2-2	385	4275.00	0.0921	1	0	10.9	0.0010	10.9	0.0010	3/9/99
1821561CT	TRI-25-RA1-2	385	4390.00	0.0921	2	0	10.9	0.0010	21.7	0.0019	3/9/99
1821562CT	TRI-26-RA2-2	385	4318.00	0.0921	9	0	10.9	0.0010	97.8	0.0087	3/9/99
1821563CT	TRI-27-RAN-2	385	8824.00	0.0921	8	0	10.9	0.0005	86.9	0.0038	3/9/99
1821564CT	TRI-28-RAS-2	385	3631.00	0.0921	2	0	10.9	0.0012	21.7	0.0023	3/9/99
1821565CT	TRI-29-FS1-2	385	4234.00	0.0921	1	0	10.9	0.0010	10.9	0.0010	3/9/99
1821566CT	TRI-30-FS2-2	385	4008.00	0.0921	1	0	10.9	0.0010	10.9	0.0010	3/9/99
1821567CT	TRI-31-CH1-2	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821568CT	TRI-32-CH2-2	385	4102.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99

‡ Volumes provided by California Air Resources Board for Project C-98-063 were used to calculate analytical results and sensitivities.
† Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.

Chr - Chrysotile, Amp - Amphibole
Samples received on: Wednesday, February 24, 1999
* Results Less Than Analytical Sensitivity.
N/A - Sample not analyzed.

Authorized Signature ______________
Bernard Thomas, Project Manager

Date

Test Report

Total Asbestos Structure Concentration

TEM Level III Analysis

Project ATC902247

RJ Lee Group Sample Number	Client Sample Number	Filter Area (sq mm)	Volume ‡ (Liters)	Area Analyzed (sq mm)	Structures		Analytical Sensitivity †		Concentration		Analysis Date
					Chr	Amp	(S/sq. mm)	(S/cc)	(S/sq. mm)	(S/cc)	
1821569CT	TRI-33-WS1-3	385	4268.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821570CT	TRI-34-WS2-3	385	4275.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821571CT	TRI-35-WSN-3	385	8908.00	0.0921	0	0	10.9	0.0005	<10.9*	<0.0005*	3/9/99
1821572CT	TRI-36-WSS-3	385	1987.00	0.0921	11	0	10.9	0.0021	119.5	0.0232	3/9/99
1821573CT	TRI-37-WH1-3	385	3323.00	0.0921	0	0	10.9	0.0013	<10.9*	<0.0013*	3/9/99
1821574CT	TRI-38-WH2-3	385	4262.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821575CT	TRI-39-TLR1-3	385	4253.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821576CT	TRI-40-TLR2-3	385	4253.00	0.0921	1	0	10.9	0.0010	10.9	0.0010	3/9/99
1821577CT	TRI-41-RA1-3	385	4289.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821578CT	TRI-42-RA2-3	385	4291.00	0.0921	1	0	10.9	0.0010	10.9	0.0010	3/9/99
1821579CT	TRI-43-RAN-3	385	7241.00	0.0921	0	0	10.9	0.0006	<10.9*	<0.0006*	3/9/99
1821580CT	TRI-44-RAS-3	385	4619.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	3/9/99
1821581CT	TRI-45-FS1-3	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821582CT	TRI-46-FS2-3	385	4282.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821583CT	TRI-47-CH1-3	385	4196.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821584CT	TRI-48-CH2-3	385	4253.00	0.0921	1	0	10.9	0.0010	10.9	0.0010	3/9/99

‡ Volumes provided by California Air Resources Board for Project C-98-063 were used to calculate analytical results and sensitivities.

†Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.

Chr - Chrysotile, Amp - Amphibole
Samples received on: Wednesday, February 24, 1999
* Results Less Than Analytical Sensitivity.
N/A - Sample not analyzed.

Authorized Signature ____________________
Bernard Thomas, Project Manager

Date

Test Report

Total Asbestos Structure Concentration
TEM Level III Analysis
Project ATC902247

RJ Lee Group Sample Number	Client Sample Number	Filter Area (sq mm)	Volume ‡ (Liters)	Area Analyzed (sq mm)	Structures		Analytical Sensitivity †		Concentration		Analysis Date
					Chr	Amp	(S/sq. mm)	(S/cc)	(S/sq. mm)	(S/cc)	
1821585CT	TRI-49-BUDS-2	385	4320.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821586CT	TRI-50-BUDS-1	385	4320.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99

‡ Volumes provided by California Air Resources Board for Project C-98-063 were used to calculate analytical results and sensitivities.

†Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.

Chr - Chrysotile, Amp - Amphibole
Samples received on: Wednesday, February 24, 1999
* Results Less Than Analytical Sensitivity.
N/A - Sample not analyzed.

Authorized Signature
Bernard Thomas, Project Manager
Date Date Wednesday, March 10, 1999

Table II

Asbestos Concentration for Structures ≥ 5 µm in Length

TEM Level III Analysis

Project ATC902247

RJ Lee Group Sample Number	Client Sample Number	Filter Area (sq mm)	Volume ‡ (Liters)	Area Analyzed (sq mm)	Structures ≥5 µm Chr	Structures ≥5 µm Amp	Analytical Sensitivity † (S/sq. mm)	Analytical Sensitivity † (S/cc)	Concentration for Structures ≥ 5 µm (S/sq. mm)	Concentration for Structures ≥ 5 µm (S/cc)	Analysis Date
1821537CT	TRI-1-WS1-1	385	4441.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	3/9/99
1821538CT	TRI-2-WS2-1	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821539CT	TRI-3-WSN-1	385	11610.00	0.0921	0	0	10.9	0.0004	<10.9*	<0.0004*	3/9/99
1821540CT	TRI-4-WSS-1	385	1313.00	0.0921	0	0	10.9	0.0032	<10.9*	<0.0032*	3/9/99
1821541CT	TRI-5-WH1-1	385	4309.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821542CT	TRI-6-WH2-1	385	4307.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821543CT	TRI-7-TLR1-1	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821544CT	TRI-8-TLR2-1	385	4217.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821545CT	TRI-9-RA1-1	385	4189.00	0.0921	1	0	10.9	0.0010	10.9	0.0010	3/9/99
1821546CT	TRI-10-RA2-1	385	4282.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821547CT	TRI-11-RAN-1	385	6890.00	0.0921	1	0	10.9	0.0006	10.9	0.0006	3/9/99
1821548CT	TRI-12-RAS-1	385	6948.00	0.0921	1	0	10.9	0.0006	10.9	0.0006	3/9/99
1821549CT	TRI-13-FS1-1	385	4320.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821550CT	TRI-14-FS2-1	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821551CT	TRI-15-CH1-1	385	4297.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821552CT	TRI-16-CH2-1	385	1922.00	0.0921	0	0	10.9	0.0022	<10.9*	<0.0022*	3/9/99
1821553CT	TRI-17-WS1-2	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821554CT	TRI-18-WS2-2	385	4444.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	3/9/99

‡ Volumes provided by California Air Resources Board for Project C-98-063 were used to calculate analytical results and sensitivities.
†Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.

Chr - Chrysotile, Amp - Amphibole
Samples received on: Wednesday, February 24, 1999
* Results Less Than Analytical Sensitivity.
N/A - Sample not analyzed.

Authorized Signature ______________________
Bernard Thomas, Project Manager

Date

Table II
Asbestos Concentration for Structures ≥ 5 µm in Length
TEM Level III Analysis
Project ATC902247

RJ Lee Group Sample Number	Client Sample Number	Filter Area (sq mm)	Volume ‡ (Liters)	Area Analyzed (sq mm)	Structures ≥5 µm Chr	Amp	Analytical Sensitivity † (S/sq. mm)	(S/cc)	Concentration for Structures ≥ 5 µm (S/sq. mm)	(S/cc)	Analysis Date
1821555CT	TRI-19-WSN-2	385	9741.00	0.0921	0	0	10.9	0.0004	<10.9*	<0.0004*	3/9/99
1821556CT	TRI-20-WSS-2	385	2655.00	0.0921	0	0	10.9	0.0016	<10.9*	<0.0016*	3/9/99
1821557CT	TRI-21-WH1-2	385	4462.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	3/9/99
1821558CT	TRI-22-WH2-2	385	4462.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	3/9/99
1821559CT	TRI-23-TLR1-2	385	4275.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821560CT	TRI-24-TLR2-2	385	4275.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821561CT	TRI-25-RA1-2	385	4390.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821562CT	TRI-26-RA2-2	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821563CT	TRI-27-RAN-2	385	8824.00	0.0921	2	0	10.9	0.0005	21.7	0.0009	3/9/99
1821564CT	TRI-28-RAS-2	385	3631.00	0.0921	0	0	10.9	0.0012	<10.9*	<0.0012*	3/9/99
1821565CT	TRI-29-FS1-2	385	4234.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821566CT	TRI-30-FS2-2	385	4008.00	0.0921	1	0	10.9	0.0010	10.9	0.0010	3/9/99
1821567CT	TRI-31-CH1-2	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821568CT	TRI-32-CH2-2	385	4102.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821569CT	TRI-33-WS1-3	385	4268.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821570CT	TRI-34-WS2-3	385	4275.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821571CT	TRI-35-WSN-3	385	8908.00	0.0921	0	0	10.9	0.0005	<10.9*	<0.0005*	3/9/99
1821572CT	TRI-36-WSS-3	385	1987.00	0.0921	0	0	10.9	0.0021	<10.9*	<0.0021*	3/9/99

‡ Volumes provided by California Air Resources Board for Project C-98-063 were used to calculate analytical results and sensitivities.
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Chr - Chrysotile, Amp - Amphibole
Samples received on: Wednesday, February 24, 1999
* Results Less Than Analytical Sensitivity.
N/A - Sample not analyzed.

Authorized Signature
Bernard Thomas, Project Manager
Date

Table II

Asbestos Concentration for Structures ≥ 5 µm in Length

TEM Level III Analysis

Project ATC902247

RJ Lee Group Sample Number	Client Sample Number	Filter Area (sq mm)	Volume ‡ (Liters)	Area Analyzed (sq mm)	Structures ≥5 µm		Analytical Sensitivity †		Concentration for Structures ≥ 5 µm		Analysis Date
					Chr	Amp	(S/sq. mm)	(S/cc)	(S/sq. mm)	(S/cc)	
1821573CT	TRI-37-WH1-3	385	3323.00	0.0921	0	0	10.9	0.0013	<10.9*	<0.0013*	3/9/99
1821574CT	TRI-38-WH2-3	385	4262.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821575CT	TRI-39-TLR1-3	385	4253.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821576CT	TRI-40-TLR2-3	385	4253.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821577CT	TRI-41-RA1-3	385	4289.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821578CT	TRI-42-RA2-3	385	4291.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821579CT	TRI-43-RAN-3	385	7241.00	0.0921	0	0	10.9	0.0006	<10.9*	<0.0006*	3/9/99
1821580CT	TRI-44-RAS-3	385	4619.00	0.0921	0	0	10.9	0.0009	<10.9*	<0.0009*	3/9/99
1821581CT	TRI-45-FS1-3	385	4318.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821582CT	TRI-46-FS2-3	385	4282.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821583CT	TRI-47-CH1-3	385	4196.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821584CT	TRI-48-CH2-3	385	4253.00	0.0921	1	0	10.9	0.0010	10.9	0.0010	3/9/99
1821585CT	TRI-49-BUDS-2	385	4320.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99
1821586CT	TRI-50-BUDS-1	385	4320.00	0.0921	0	0	10.9	0.0010	<10.9*	<0.0010*	3/9/99

‡ Volumes provided by California Air Resources Board for Project C-98-063 were used to calculate analytical results and sensitivities.
†Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.
Chr - Chrysotile, Amp - Amphibole
Samples received on: Wednesday, February 24, 1999
* Results Less Than Analytical Sensitivity.
N/A - Sample not analyzed.

Authorized Signature ____________________
Bernard Thomas, Project Manager

Date

Table V
Total Poisson Asbestos Concentrations
TEM Level III Analysis
Project ATC902247

Sample Number	Client Sample Number	Actual Counts	Poisson Range		Lower Concentration Bounds ‡		Upper Concentration Bounds ‡		Analysis
			Lower	Upper	S/sq mm	S/cc	S/sq mm	S/cc	Date
1821537CT	TRI-1-WS1-1	3	1	9	10.86	0.0009	97.76	0.0085	3/9/99
1821538CT	TRI-2-WS2-1	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821539CT	TRI-3-WSN-1	1	0	6	0.00	0.0000	65.18	0.0022	3/9/99
1821540CT	TRI-4-WSS-1	1	0	6	0.00	0.0000	65.18	0.0191	3/9/99
1821541CT	TRI-5-WH1-1	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821542CT	TRI-6-WH2-1	1	0	6	0.00	0.0000	65.18	0.0058	3/9/99
1821543CT	TRI-7-TLR1-1	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821544CT	TRI-8-TLR2-1	9	4	17	43.45	0.0040	184.66	0.0169	3/9/99
1821545CT	TRI-9-RA1-1	5	2	12	21.73	0.0020	130.35	0.0120	3/9/99
1821546CT	TRI-10-RA2-1	3	1	9	10.86	0.0010	97.76	0.0088	3/9/99
1821547CT	TRI-11-RAN-1	2	0	7	0.00	0.0000	76.04	0.0042	3/9/99
1821548CT	TRI-12-RAS-1	1	0	6	0.00	0.0000	65.18	0.0036	3/9/99
1821549CT	TRI-13-FS1-1	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821550CT	TRI-14-FS2-1	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821551CT	TRI-15-CH1-1	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821552CT	TRI-16-CH2-1	0	0	4	<10.86*	<0.0022*	43.45	0.0087	3/9/99
1821553CT	TRI-17-WS1-2	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821554CT	TRI-18-WS2-2	0	0	4	<10.86*	<0.0009*	43.45	0.0038	3/9/99
1821555CT	TRI-19-WSN-2	0	0	4	<10.86*	<0.0004*	43.45	0.0017	3/9/99
1821556CT	TRI-20-WSS-2	0	0	4	<10.86*	<0.0016*	43.45	0.0063	3/9/99

‡ Volumes provided by California Air Resources Board for Project C-98-063 were used to calculate analytical results and sensitivities.
† Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.
Samples received on: Wednesday, February 24, 1999
Chr - Chrysotile, Amp - Amphibole

Authorized Signature
Bernard Thomas, Project Manager

N/A - Sample not analyzed.

Table V

Total Poisson Asbestos Concentrations
TEM Level III Analysis

Project ATC902247

			Poisson Range		Lower Concentration Bounds ‡		Upper Concentration Bounds ‡		Analysis
Sample Number	Client Sample Number	Actual Counts	Lower	Upper	S/sq mm	S/cc	S/sq mm	S/cc	Date
1821557CT	TRI-21-WH1-2	0	0	4	<10.86*	<0.0009*	43.45	0.0037	3/9/99
1821558CT	TRI-22-WH2-2	0	0	4	<10.86*	<0.0009*	43.45	0.0037	3/9/99
1821559CT	TRI-23-TLR1-2	8	3	16	32.59	0.0029	173.80	0.0157	3/9/99
1821560CT	TRI-24-TLR2-2	1	0	6	0.00	0.0000	65.18	0.0059	3/9/99
1821561CT	TRI-25-RA1-2	2	0	7	0.00	0.0000	76.04	0.0067	3/9/99
1821562CT	TRI-26-RA2-2	9	4	17	43.45	0.0039	184.66	0.0165	3/9/99
1821563CT	TRI-27-RAN-2	8	3	16	32.59	0.0014	173.80	0.0076	3/9/99
1821564CT	TRI-28-RAS-2	2	0	7	0.00	0.0000	76.04	0.0081	3/9/99
1821565CT	TRI-29-FS1-2	1	0	6	0.00	0.0000	65.18	0.0059	3/9/99
1821566CT	TRI-30-FS2-2	1	0	6	0.00	0.0000	65.18	0.0063	3/9/99
1821567CT	TRI-31-CH1-2	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821568CT	TRI-32-CH2-2	0	0	4	<10.86*	<0.0010*	43.45	0.0041	3/9/99
1821569CT	TRI-33-WS1-3	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821570CT	TRI-34-WS2-3	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821571CT	TRI-35-WSN-3	0	0	4	<10.86*	<0.0005*	43.45	0.0019	3/9/99
1821572CT	TRI-36-WSS-3	11	5	20	54.31	0.0105	217.25	0.0421	3/9/99
1821573CT	TRI-37-WH1-3	0	0	4	<10.86*	<0.0013*	43.45	0.0050	3/9/99
1821574CT	TRI-38-WH2-3	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821575CT	TRI-39-TLR1-3	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821576CT	TRI-40-TLR2-3	1	0	6	0.00	0.0000	65.18	0.0059	3/9/99

‡ Volumes provided by California Air Resources Board for Project C-98-063 were used to calculate analytical results and sensitivities.

†Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.

Samples received on: Wednesday, February 24, 1999
Chr - Chrysotile, Amp - Amphibole

Authorized Signature ____________
Bernard Thomas, Project Manager

N/A - Sample not analyzed.

Table V

Total Poisson Asbestos Concentrations
TEM Level III Analysis
Project ATC902247

			Poisson Range		Lower Concentration Bounds ‡		Upper Concentration Bounds ‡		Analysis
Sample Number	Client Sample Number	Actual Counts	Lower	Upper	S/sq mm	S/cc	S/sq mm	S/cc	Date
1821577CT	TRI-41-RA1-3	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821578CT	TRI-42-RA2-3	1	0	6	0.00	0.0000	65.18	0.0058	3/9/99
1821579CT	TRI-43-RAN-3	0	0	4	<10.86*	<0.0006*	43.45	0.0023	3/9/99
1821580CT	TRI-44-RAS-3	0	0	4	<10.86*	<0.0009*	43.45	0.0036	3/9/99
1821581CT	TRI-45-FS1-3	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821582CT	TRI-46-FS2-3	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821583CT	TRI-47-CH1-3	0	0	4	<10.86*	<0.0010*	43.45	0.0040	3/9/99
1821584CT	TRI-48-CH2-3	1	0	6	0.00	0.0000	65.18	0.0059	3/9/99
1821585CT	TRI-49-BUDS-2	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99
1821586CT	TRI-50-BUDS-1	0	0	4	<10.86*	<0.0010*	43.45	0.0039	3/9/99

‡ Volumes provided by California Air Resources Board for Project C-98-063 were used to calculate analytical results and sensitivities.
†Analytical sensitivity is the calculated concentration based on one structure in the area analyzed.

Samples received on: Wednesday, February 24, 1999
Chr - Chrysotile, Amp - Amphibole

Authorized Signature
Bernard Thomas, Project Manager

N/A - Sample not analyzed.

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12941
RJL Sample #	1821537CT	**Grid Openings**	10
Client Sample #	TRI-1-WS1-1	**Total Asbestos**	3
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4441.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	0.90	0.12	Chrysotile	BM			0486		
1	2	0.40	0.10	Chrysotile				X		
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	1	1.40	0.10	Chrysotile	M			X		
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12941
RJL Sample #	1821538CT	**Grid Openings**	10
Client Sample #	TRI-2-WS2-1	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4318.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee *Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12941
RJL Sample #	1821539CT	**Grid Openings**	10
Client Sample #	TRI-3-WSN-1	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	11610.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	2.70	0.40	Chrysotile	B			X		
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC902247	**RJL QA Number**	CQ12941
RJL Sample #	1821541CT	**Grid Openings**	10
Client Sample #	TRI-5-WH1-1	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4309.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	15.00	1.00	Unknown				X		
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group*, Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12941
RJL Sample #	1821540CT	**Grid Openings**	10
Client Sample #	TRI-4-WSS-1	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm ^{2}
Magnification	20000 X	**Volume**	1313.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm ^{2}
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	1	1.00	0.13	Chrysotile	B			X	0488	
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12941
RJL Sample #	**1821541CT**	**Grid Openings**	10
Client Sample #	TRI-5-WH1-1	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4309.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	15.00	1.00	Unknown				X		
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12941
RJL Sample #	**1821542CT**	**Grid Openings**	10
Client Sample #	TRI-6-WH2-1	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4307.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	1	1.00	0.05	Chrysotile	M1			X		
9	0			NSD						
10	1	0.75	0.15	Ambiguous	M1			X		

NSD - No Structures Detected

RJ Lee*Group* , Inc
Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12941
RJL Sample #	**1821543CT**	**Grid Openings**	10
Client Sample #	TRI-7-TLR1-1	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4318.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12941
RJL Sample #	1821544CT	**Grid Openings**	10
Client Sample #	TRI-8-TLR2-1	**Total Asbestos**	9
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4217.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	1	1.50	0.15	Nonasbestos	M					
5	0			NSD						
6	0			NSD						
7	1	4.00	0.30	Chrysotile	B			X		
8	0			NSD						
9	1	0.50	0.05	Chrysotile				X		
9	2	0.75	0.03	Chrysotile				X		
9	3	0.50	0.10	Chrysotile				X		
9	4	0.70	0.04	Chrysotile				X		
9	5	3.50	0.07	Chrysotile				X		
9	6	2.25	0.05	Chrysotile				X		
9	7	2.20	0.50	Chrysotile				X		
9	8	0.50	0.10	Chrysotile				X		
10	0			NSD						

NSD - No Structures Detected

RJ Lee *Group* , Inc
Count Sheet

Client Name	California Air Resources Board			
Project Number	ATC902247		**RJL QA Number**	CQ12941
RJL Sample #	1821545CT		**Grid Openings**	10
Client Sample #	TRI-9-RA1-1		**Total Asbestos**	5
Microscope	1200 EX		**Total Non-Asbestos**	1
Accelerating Volt	100 Kv		**Filter**	CE 385 mm^2
Magnification	20000 X		**Volume**	4189.0 Liters
Analyst	MB		**Grid Opening Area**	0.0092 mm^2
EDS Disk			**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	1	1.00	0.10	Chrysotile				X		
7	1	9.00	0.15	Nonasbestos						
7	2	2.75	0.05	Chrysotile				X		
8	1	2.25	0.50	Chrysotile				X		
8	2	6.50	0.75	Chrysotile	B			X		
8	3	3.50	0.25	Chrysotile	B			X		
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12941
RJL Sample #	**1821546CT**	**Grid Openings**	10
Client Sample #	TRI-10-RA2-1	**Total Asbestos**	3
Microscope	1200 EX	**Total Non-Asbestos**	2
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4282.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	1	2.20	0.10	Chrysotile	M			X		
3	0			NSD						
4	0			NSD						
5	1	1.50	0.10	Ambiguous	M2					
5	2	2.80	0.25	Chrysotile	BM			X		
6	0			NSD						
7	1	2.10	0.15	Chrysotile				0488		
8	1	3.70	0.10	Ambiguous	M					
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc
Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12941
RJL Sample #	**1821547CT**	**Grid Openings**	10
Client Sample #	TRI-11-RAN-1	**Total Asbestos**	2
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	6890.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	1	1.00	0.12	Chrysotile	BM			X		
5	0			NSD						
6	1	6.50	0.50	Chrysotile	BM			X		
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	1	0.60	0.10	Ambiguous	M					

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12941
RJL Sample #	**1821548CT**	**Grid Openings**	10
Client Sample #	TRI-12-RAS-1	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	6948.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	1	6.20	0.80	Chrysotile	BM			0489		
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group*, Inc

Count Sheet

Client Name California Air Resources Board
Project Number ATC902247
RJL Sample # 1821549CT
Client Sample # TRI-13-FS1-1
Microscope 1200 EX
Accelerating Volt 100 Kv
Magnification 20000 X
Analyst YZ
EDS Disk

RJL QA Number CQ12941
Grid Openings 10
Total Asbestos 0
Total Non-Asbestos 0
Filter CE 385 mm^2
Volume 4320.0 Liters
Grid Opening Area 0.0092 mm^2
Dilution Factor 1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group*, Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12942
RJL Sample #	**1821550CT**	**Grid Openings**	10
Client Sample #	TRI-14-FS2-1	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4318.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12942
RJL Sample #	1821551CT	**Grid Openings**	10
Client Sample #	TRI-15-CH1-1	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4297.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC902247	**RJL QA Number**	CQ12942
RJL Sample #	1821551CT	**Grid Openings**	10
Client Sample #	TRI-15-CH1-1	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4297.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12942
RJL Sample #	1821552CT	**Grid Openings**	10
Client Sample #	TRI-16-CH2-1	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	1922.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12942
RJL Sample #	1821553CT	**Grid Openings**	10
Client Sample #	TRI-17-WS1-2	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4318.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC902247	**RJL QA Number**	CQ12942
RJL Sample #	1821555CT	**Grid Openings**	10
Client Sample #	TRI-19-WSN-2	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	9741.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12942
RJL Sample #	**1821556CT**	**Grid Openings**	10
Client Sample #	TRI-20-WSS-2	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	2655.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12942
RJL Sample #	1821557CT	**Grid Openings**	10
Client Sample #	TRI-21-WH1-2	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4462.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12942
RJL Sample #	1821558CT	**Grid Openings**	10
Client Sample #	TRI-22-WH2-2	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4462.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee *Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12942
RJL Sample #	1821559CT	**Grid Openings**	10
Client Sample #	TRI-23-TLR1-2	**Total Asbestos**	8
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm ^{2}
Magnification	20000 X	**Volume**	4275.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm ^{2}
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	1	3.20	0.12	Chrysotile	BM			0492		
3	1	1.50	0.10	Ambiguous	M					
3	2	0.60	0.14	Chrysotile	B			X		
3	3	0.80	0.10	Chrysotile	M			X		
3	4	0.60	0.10	Chrysotile				X		
3	5	0.80	0.10	Chrysotile				X		
3	6	2.70	0.12	Chrysotile	BM			X		
3	7	0.90	0.14	Chrysotile	BM			X		
3	8	0.75	0.14	Chrysotile	BCM			X		
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12942
RJL Sample #	**1821560CT**	**Grid Openings**	10
Client Sample #	TRI-24-TLR2-2	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4275.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	1	2.90	0.12	Chrysotile	BM1			0493		
10	2	0.75	0.10	Ambiguous	M1					

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC902247	**RJL QA Number**	CQ12942
RJL Sample #	1821561CT	**Grid Openings**	10
Client Sample #	TRI-25-RA1-2	**Total Asbestos**	2
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm ^{2}
Magnification	20000 X	**Volume**	4390.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm ^{2}
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	1	2.00	0.10	Chrysotile	M1			X		
7	2	0.80	0.13	Chrysotile	B			X		
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12942
RJL Sample #	1821562CT	**Grid Openings**	10
Client Sample #	TRI-26-RA2-2	**Total Asbestos**	9
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4318.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	1.20	0.10	Chrysotile	M2			0494		
1	2	1.70	0.10	Chrysotile	M1			X		
2	1	2.00	0.12	Ambiguous	BM					
3	0			NSD						
4	1	2.00	0.12	Chrysotile	BM			X		
5	1	1.00	0.10	Chrysotile	M			X		
6	0			NSD						
7	1	3.50	0.25	Chrysotile	BM			X		
8	1	3.00	0.30	Chrysotile	BCM			X		
8	2	3.00	0.40	Chrysotile	BCM			X		
9	0			NSD						
10	1	2.70	0.25	Chrysotile	BM			X		
10	2	3.50	0.50	Chrysotile	BM			X		

NSD - No Structures Detected

RJ Lee*Group*, Inc
Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12943
RJL Sample #	1821563CT	**Grid Openings**	10
Client Sample #	TRI-27-RAN-2	**Total Asbestos**	8
Microscope	1200 EX	**Total Non-Asbestos**	2
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	8824.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	5.00	1.00	Chrysotile	B			X		
2	1	0.60	0.06	Chrysotile	M1			X		
3	1	1.25	0.05	Nonasbestos	M1			X		
3	2	1.50	0.07	Chrysotile	M1			X		
4	0			NSD						
5	1	15.00	1.00	Chrysotile	BM			X		
6	0			NSD						
7	1	1.75	0.06	Nonasbestos	M			X		
7	2	2.00	0.15	Chrysotile	M			X		
8	1	0.75	0.18	Chrysotile	M1			X		
8	2	0.50	0.04	Chrysotile	M			X		
9	1	3.00	0.35	Chrysotile	BM			X		
10	0			NSD						

NSD - No Structures Detected

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	RJL QA Number	CQ12943
RJL Sample #	1821564CT	Grid Openings	10
Client Sample #	TRI-28-RAS-2	Total Asbestos	2
Microscope	1200 EX	Total Non-Asbestos	0
Accelerating Volt	100 Kv	Filter	CE 385 mm^2
Magnification	20000 X	Volume	3631.0 Liters
Analyst	MB	Grid Opening Area	0.0092 mm^2
EDS Disk		Dilution Factor	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	3.00	0.20	Chrysotile	M2			X		
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	1	0.80	0.05	Chrysotile	M1			X		
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12943
RJL Sample #	1821565CT	**Grid Openings**	10
Client Sample #	TRI-29-FS1-2	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4234.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	2.75	0.25	Chrysotile	BM			X		
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group*, Inc
Count Sheet

Client Name	California Air Resources Board			
Project Number	ATC902247		**RJL QA Number**	CQ12943
RJL Sample #	1821566CT		**Grid Openings**	10
Client Sample #	TRI-30-FS2-2		**Total Asbestos**	1
Microscope	1200 EX		**Total Non-Asbestos**	1
Accelerating Volt	100 Kv		**Filter**	CE 385 mm^2
Magnification	20000 X		**Volume**	4008.0 Liters
Analyst	MB		**Grid Opening Area**	0.0092 mm^2
EDS Disk			**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	1	20.00	1.25	Chrysotile	BM			X		
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	1	15.00	1.50	Nonasbestos				X		

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC902247	**RJL QA Number**	CQ12943
RJL Sample #	1821567CT	**Grid Openings**	10
Client Sample #	TRI-31-CH1-2	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm ^{2}
Magnification	20000 X	**Volume**	4318.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm ^{2}
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12943
RJL Sample #	1821568CT	**Grid Openings**	10
Client Sample #	TRI-32-CH2-2	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4102.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12943
RJL Sample #	1821569CT	**Grid Openings**	10
Client Sample #	TRI-33-WS1-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4268.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group*, Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12943
RJL Sample #	**1821570CT**	**Grid Openings**	10
Client Sample #	TRI-34-WS2-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 **Kv**	**Filter**	CE 385 mm ^{2}
Magnification	20000 X	**Volume**	4275.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm ^{2}
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC902247	**RJL QA Number**	CQ12943
RJL Sample #	1821571CT	**Grid Openings**	10
Client Sample #	TRI-35-WSN-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	8908.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee *Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12943
RJL Sample #	1821572CT	**Grid Openings**	10
Client Sample #	TRI-36-WSS-3	**Total Asbestos**	11
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	1987.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	1.50	0.20	Chrysotile	M2			X		
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	1	0.80	0.04	Chrysotile				X		
5	2	0.70	0.03	Chrysotile				X		
5	3	0.50	0.04	Chrysotile				X		
5	4	0.50	0.04	Chrysotile				X		
5	5	0.65	0.05	Chrysotile				X		
5	6	0.40	0.05	Chrysotile				X		
5	7	0.40	0.04	Chrysotile				X		
5	8	3.00	0.04	Chrysotile				X		
5	9	0.50	0.05	Chrysotile				X		
5	10	0.45	0.04	Chrysotile				X		
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee *Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12943
RJL Sample #	1821573CT	**Grid Openings**	10
Client Sample #	TRI-37-WH1-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	3
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	3323.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	0.75	0.08	Nonasbestos				X		
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	1	0.70	0.09	Nonasbestos	M1			X		
6	0			NSD						
7	0			NSD						
8	1	0.90	0.15	Nonasbestos	M2					
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12943
RJL Sample #	**1821574CT**	**Grid Openings**	10
Client Sample #	TRI-38-WH2-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4262.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee *Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12943
RJL Sample #	1821575CT	**Grid Openings**	10
Client Sample #	TRI-39-TLR1-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	2
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4253.0 Liters
Analyst	MB	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	1	1.00	0.05	Ambiguous				FAINT		
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	1	1.20	0.18	Nonasbestos				X		
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee *Group* , Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12944
RJL Sample #	1821576CT	**Grid Openings**	10
Client Sample #	TRI-40-TLR2-3	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4253.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	1	1.20	0.10	Ambiguous	M1					
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	1	3.90	0.50	Chrysotile	BM			0498		

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC902247	**RJL QA Number**	CQ12944
RJL Sample #	1821577CT	**Grid Openings**	10
Client Sample #	TRI-41-RA1-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4289.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12944
RJL Sample #	**1821578CT**	**Grid Openings**	10
Client Sample #	TRI-42-RA2-3	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4291.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	1	0.75	0.10	Nonasbestos	M1					
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	1	1.00	0.12	Chrysotile	B			X		

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12944
RJL Sample #	**1821579CT**	**Grid Openings**	10
Client Sample #	TRI-43-RAN-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	7241.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC902247	**RJL QA Number**	CQ12944
RJL Sample #	1821580CT	**Grid Openings**	10
Client Sample #	TRI-44-RAS-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4619.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group*, Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12944
RJL Sample #	**1821581CT**	**Grid Openings**	10
Client Sample #	TRI-45-FS1-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4318.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12944
RJL Sample #	**1821582CT**	**Grid Openings**	10
Client Sample #	TRI-46-FS2-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	1
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4282.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	1	2.50	0.24	Ambiguous	BM					

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC902247	**RJL QA Number**	CQ12944
RJL Sample #	1821583CT	**Grid Openings**	10
Client Sample #	TRI-47-CH1-3	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4196.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee *Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	**ATC902247**	**RJL QA Number**	CQ12944
RJL Sample #	**1821585CT**	**Grid Openings**	10
Client Sample #	TRI-49-BUDS-2	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4320.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group* , Inc

Count Sheet

Client Name	**California Air Resources Board**		
Project Number	ATC902247	**RJL QA Number**	CQ12944
RJL Sample #	1821584CT	**Grid Openings**	10
Client Sample #	TRI-48-CH2-3	**Total Asbestos**	1
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4253.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	1	12.00	0.45	Chrysotile	BCM			X		
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group*, Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12944
RJL Sample #	1821585CT	**Grid Openings**	10
Client Sample #	TRI-49-BUDS-2	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4320.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

RJ Lee*Group*, Inc

Count Sheet

Client Name	California Air Resources Board		
Project Number	ATC902247	**RJL QA Number**	CQ12944
RJL Sample #	1821586CT	**Grid Openings**	10
Client Sample #	TRI-50-BUDS-1	**Total Asbestos**	0
Microscope	1200 EX	**Total Non-Asbestos**	0
Accelerating Volt	100 Kv	**Filter**	CE 385 mm^2
Magnification	20000 X	**Volume**	4320.0 Liters
Analyst	YZ	**Grid Opening Area**	0.0092 mm^2
EDS Disk		**Dilution Factor**	1

Field	Fiber	Length µm	Width µm	Structure Type	Morph	EDS	Photo	SAED	Amphibole Type	Comment
1	0			NSD						
2	0			NSD						
3	0			NSD						
4	0			NSD						
5	0			NSD						
6	0			NSD						
7	0			NSD						
8	0			NSD						
9	0			NSD						
10	0			NSD						

NSD - No Structures Detected

Peter M. Rooney
Secretary for Environmental Protection

Air Resources Board

Barbara Riordan, Chairman
P.O. Box 2815 · 2020 L Street · Sacramento, California 95812 · www.arb.ca.gov

Pete Wilson
Governor

February 23, 1999

Kyle Bishop
Regional Sales Manager
RJ Lee Group
530 McCormick St.
San Leandro, CA 94577

Dear Mr. Bishop:

Per our Contract, enclosed are 50 samples for TEM analysis using ARB Level 3 analysis. **I need these samples analyzed within ten working days from receipt by your laboratory**. If you cannot meet this analysis time frame please contact me at (916) 263-2060. Please use the ARB Log # as the sample # in your tracking system.

Please fax the preliminary results to George Lew at (916) 263-2067. The chain of custody must be maintained so keep the samples secure and return them 60 days after analysis. Send the final results along with the completed chain of custody form to:

George Lew, Chief
Engineering and Laboratory Branch
Air Resources Board
P. O. Box 2815
600 North Market Blvd
Sacramento, CA 95814

If you have any questions call me at (916) 263-2060.

Sincerely,

James E. McCormack

James E. McCormack
Air Resources Engineer
Monitoring and Laboratory Division

FOR ARB USE ONLY
Chain of Custody Check Off Form

For samples going to RJ Lee Laboratory

1. Was the correct project # on side 1? [✓ YES] NO

2. Did submitter fill in their name? [✓ YES] NO

3. Were samples listed on side 1 in the sample box? Did the sample # and Log numbers match? [✓ YES] NO

4. Was the ARB portion of the block containing "the chain of custody seal intact information" filled out and signed? [✓ YES] NO

5. Was the ARB portion of the block containing "the chain of custody transfer information" filled out and signed? [✓ YES] NO

Witness Signature and Date Signed. 2-23-99

For samples returning from RJ Lee Laboratory

1. Was the RJ Lee Laboratory portion of the block containing "the chain of custody seal intact information" filled out and signed? YES NO

2. Was the RJ Lee Laboratory portion of the block containing "the chain of custody transfer information" filled out and signed? YES NO

Witness Signature and Date Signed. ____________________

Appendix E-7

Studies Used in the 1990 Technical Staff Report

FOR ARB USE ONLY

Chain of Custody Check Off Form

For samples going to RJ Lee Laboratory

1. Was the correct Project # on side 1? [✓ YES] NO

2. Did submitter fill in their name? [✓ YES] NO

3. Were samples listed on side 1 in the sample box? Did the sample # and Log numbers match? [✓ YES] NO

4. Was the ARB portion of the block containing "the chain of custody seal intact information" filled out and signed? [✓ YES] NO

5. Was the ARB portion of the block containing "the chain of custody transfer information" filled out and signed? [✓ YES] NO

Witness Signature and Date Signed. 2-23-99

For samples returning from RJ Lee Laboratory

1. Was the RJ Lee Laboratory portion of the block containing "the chain of custody seal intact information" filled out and signed? YES NO

2. Was the RJ Lee Laboratory portion of the block containing "the chain of custody transfer information" filled out and signed? YES NO

Witness Signature and Date Signed. ______________________

Lake County Air Quality Management District
Asbestos Road Study

LAKE COUNTY AIR QUALITY
MANAGEMENT DISTRICT
— OFFICE AND LABORATORY —

883 Lakeport Blvd.
Lakeport, California 95453
Telephone: 707/263-7000
Burn Info.: 707/263-3121

ROBERT L. REYNOLDS
Air Pollution Control Officer
Noise Control Officer

April 22, 1988

Mr. Eric Johnson
Bureau of Land Management
555 Leslie St.
Ukiah CA 95482

RE: Knoxville Asbestos Sampling 2/22/88

Dear Mr. Johnson:

Please find enclosed a copy of our report regarding the above asbestos sampling. We have provided copies of the laboratory analysis under separate cover and can provide additional copies if necessary.

The District believes that the sampling is representative of exposures likely to be encountered in aggressive recreational activities involving small groups of participants. The sampling was conducted during the first lengthy dry period after the winter season and represents a relatively lower dust potential than would be expected during the drier portions of the year and use impacts causing road dust buildup and thus probably underestimates exposure levels during portions of the year.

Should you require additional information in this regard please give me a call. We will forward the invoicing for our services under separate cover. Your cooperation in this effort has been appreciated.

Sincerely,

Ross L. Kauper

cc: Chron
BLM file

KNOXVILLE ASBESTOS SURVEY

LAKE COUNTY AIR QUALITY MANAGEMENT DISTRICT

APRIL 15, 1988

DESCRIPTION & BACKGROUND

Sampling for asbestos from road generated dust was conducted by District and BLM personnel on February 22, 1988 (Eric Johnson, BLM; John Thompson and Lowell Grant, LCAQMD). This test was performed at BLM's request to gather technical data to be considered as part of a NEPA document considering the area for an Off Road Vehicle (ORV) area. Three sample traverses were made of the area roads in an effort to simulate the exposure level of asbestos to those using the area for recreational purposes.

The exact route chosen for monitoring was determined by BLM personnel, in an effort to generate a representative sample of dust found throughout the entire area.

SAMPLING METHOD

Dust was generated by driving a Ramcharger 4x4 at an average speed of approximately sixteen (16) M.P.H. over the roads shown in attached maps. This speed was determined maximum safe rate of travel over this terrain. Samples were collected on 25mm polycarbonate filters in styrene cassettes, prepared and provided by Science Application International Corp. (SAIC). Sample cassettes were mounted on the right side mirror of a Suburban 4x4. This location was chosen to most closely simulate the respiratory zone of humans in both two and four wheeled vehicles.

The sample vehicle followed the Ramcharger as closely as was safely possible (varying from 15 to 100 feet depending on speed and road condition). Sample volume, corrected to standard pressure and temperature, was supplied to SAIC for the calculation of asbestos concentration results. Copies of the field test report, volume calculations, maps detailing sample routes, and a diagram of the sample train are attached.
Four sample cassettes (one for each sample run plus a field blank) were returned to the SAIC laboratory for transmission electron microscope analysis for asbestos fibers.

Results

The results for the three sample runs, plus the field blank analysis for asbestos and non-asbestos fibers, are presented in Attachment 1 and summarized below.

Sample	Start Time	Sample Volume	Fibers/cc Non-Asbestos	Fibers/cc Asbestos
Knox 1	10:05	180.0 liters	Not Detected	14.800
Knox 2	11:25	181.0 liters	0.0913	10.700
Knox 3	12:55	195.2 liters	Not Detected	17.800
Blank		1.0 liters*	Not Detected	Not Detected

*1.0 liter volume figure assumed by lab for analysis purposes

During the test, temperature varied from 67 to 78 degrees Fahrenheit, with relative humidity ranging from 37% to 30%, winds remained low throughout the test period. Conditions during the sample period were conducive to dust generation, as rain had not been recorded at the adjacent Homestake Mining Company site since January 29, over three weeks prior to this test. Sample material was observed on the inner surface of the sample cassettes, but was not included in fiber count.

The District believes that this series of tests approximates the exposure levels to road users of this area under similar conditions (mildly competitive), while the first series of tests, performed on September 29, 1987, approximates the exposure levels of those camping in the area, but not actively involved in off road activities. The test conditions are considered conservative compared to conditions existent during the summer and fall, when there would be an increase in road use and lower soil moisture contributing to greater potential for dust generation.

Submitted By:

Ross L. Kauper

Attachments: SAIC Analysis Report
Maps of Sample Routes
Field Report of Lowell Grant
Diagram of Sample Train

RLK/LAG

Lake County Air Quality Management District
883 Lakeport Blvd.
Lakeport, California 95453
707-263-7000

-MEMORANDUM-

TO: BLM ASBESTOS FILE

FROM: Lowell Grant

SUBJECT: Sampling activity of 2/22/88

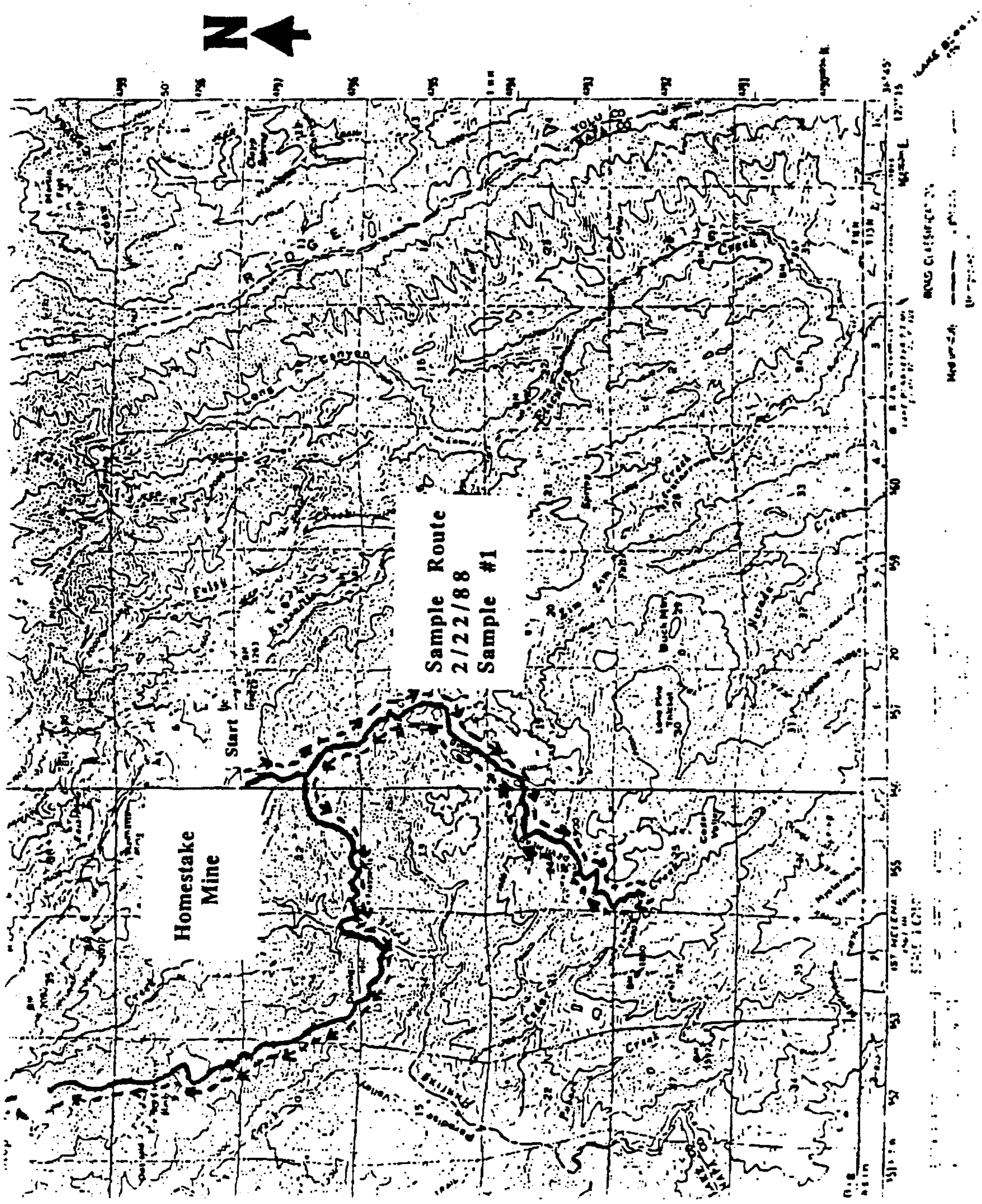
Eric Johnson, BLM, and I arrived at the turn-off for the Red Elephant Mine Rd. at 0930 PST. I then assembled the sample train (see attached diagram), and determined the R.H. to be 37% using a sling psychrometer, winds were calm, temp.=67 F. John Thompson arrived just as this was completed to audit the procedure. A leak check showed a slight leak, which was corrected, video tape of sample train was made. Sampling began at 1005 PST, with Eric Johnson driving a 4wd Ramcharger and the District sample vehicle following as closely as possible.

SAMPLE #1
START/ 1005 PST/ Odometer=39065.1/ Rotameter=68/ E.T.=203.4
END/ 1105 PST/ Odometer=39081.9/ Rotameter= 68/ E.T.= 204.4
AVERAGE SAMPLE FLOW= 3.0 LPM

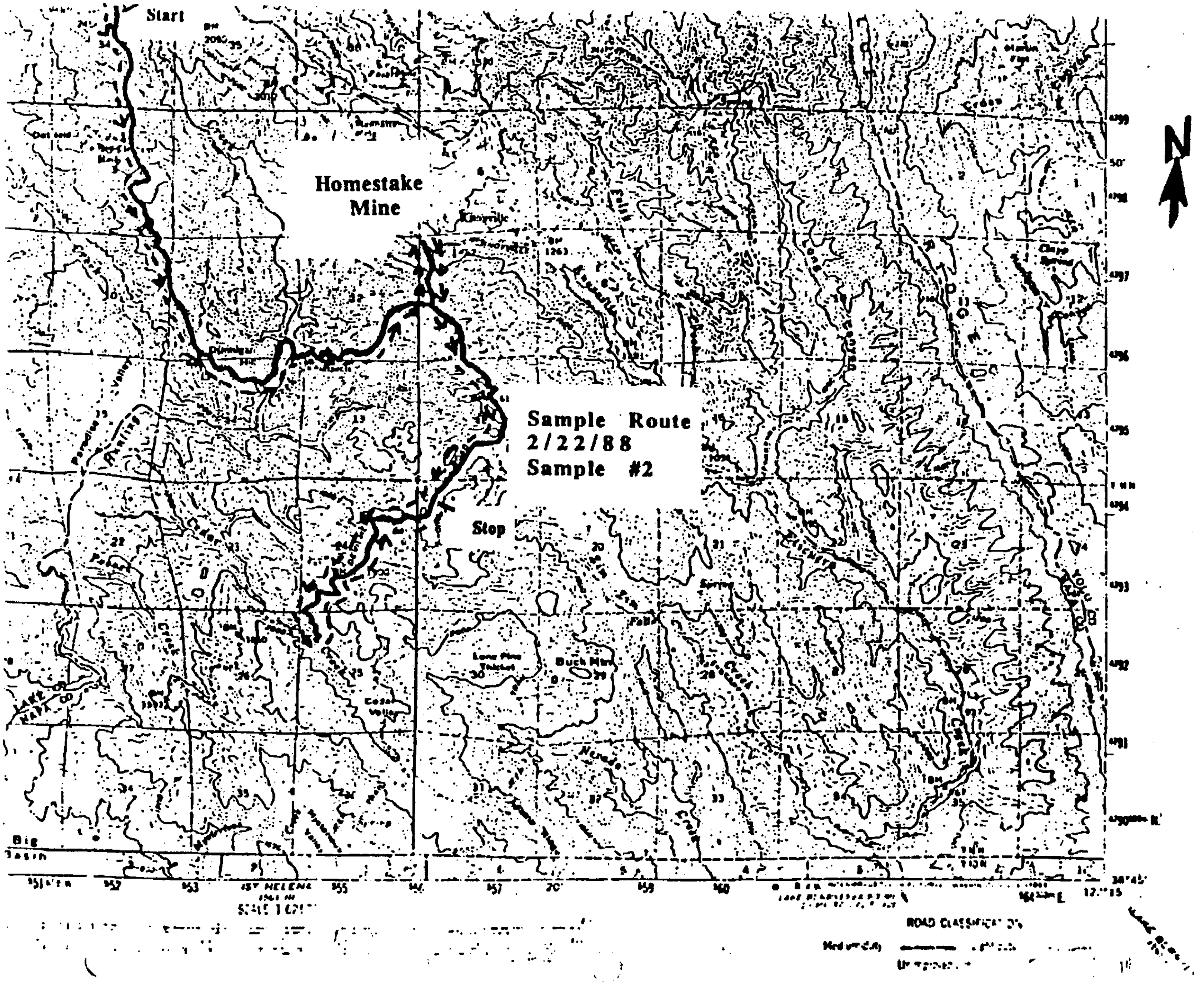
SAMPLE #2
START/ 1125 PST/ Odometer=39081.9/ Rotameter=68/ E.T.=204.5
END/ 1225 PST/ Odometer= 39097.0/ Rotameter= 71/ E.T.= 205.5
AVERAGE SAMPLE FLOW= 3.1 LPM

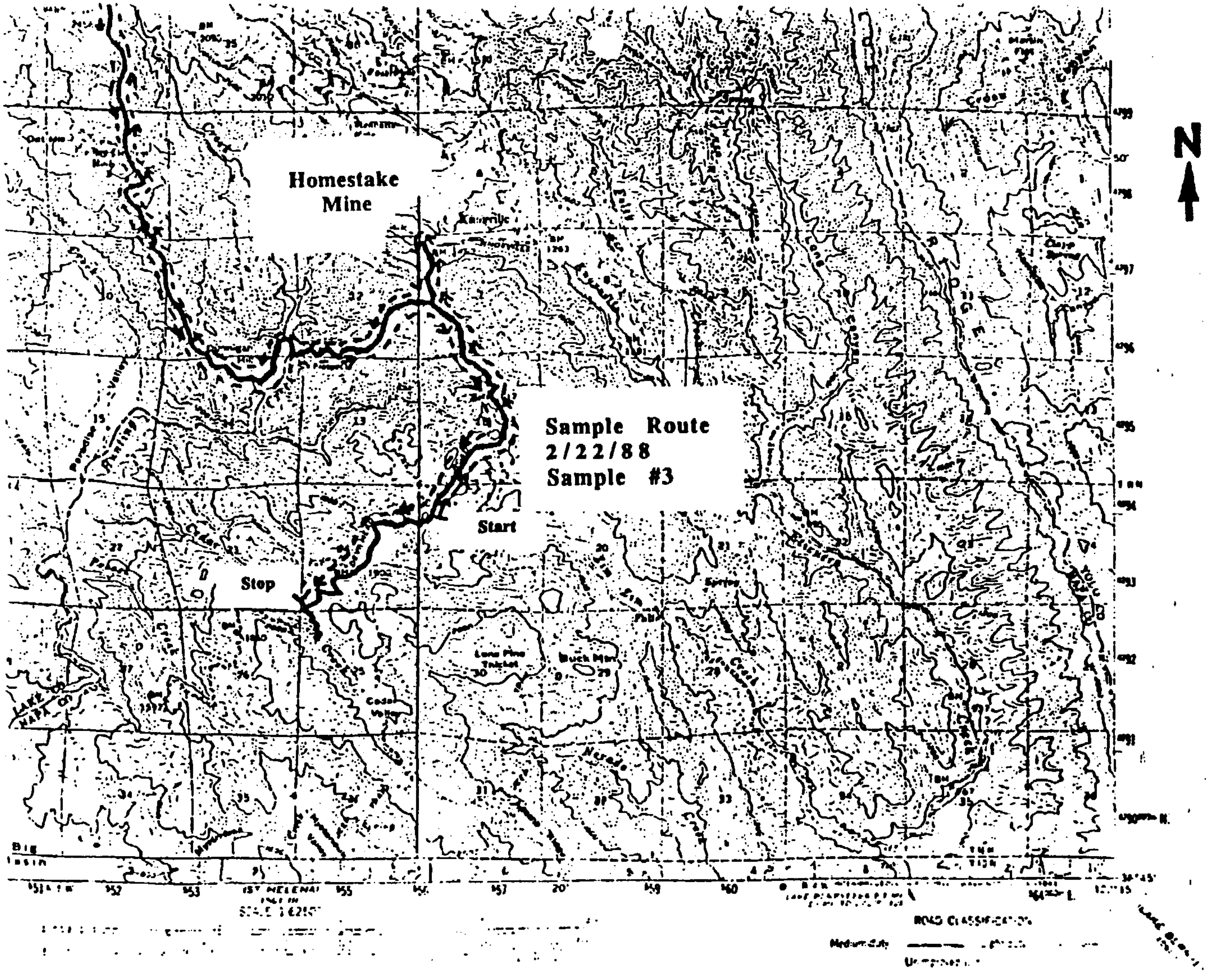
SAMPLE #3
START/ 1255 PST/ Odometer= 39097.0/ Rotameter=71/ E.T.=205.5
END/ 1355 PST/ Odometer= 39113.4/ Rotameter= 72/ E.T.=206.5
AVERAGE SAMPLE FLOW= 3.2 LPM

Temp. at end of test was 78 F, R.H. was 30%.

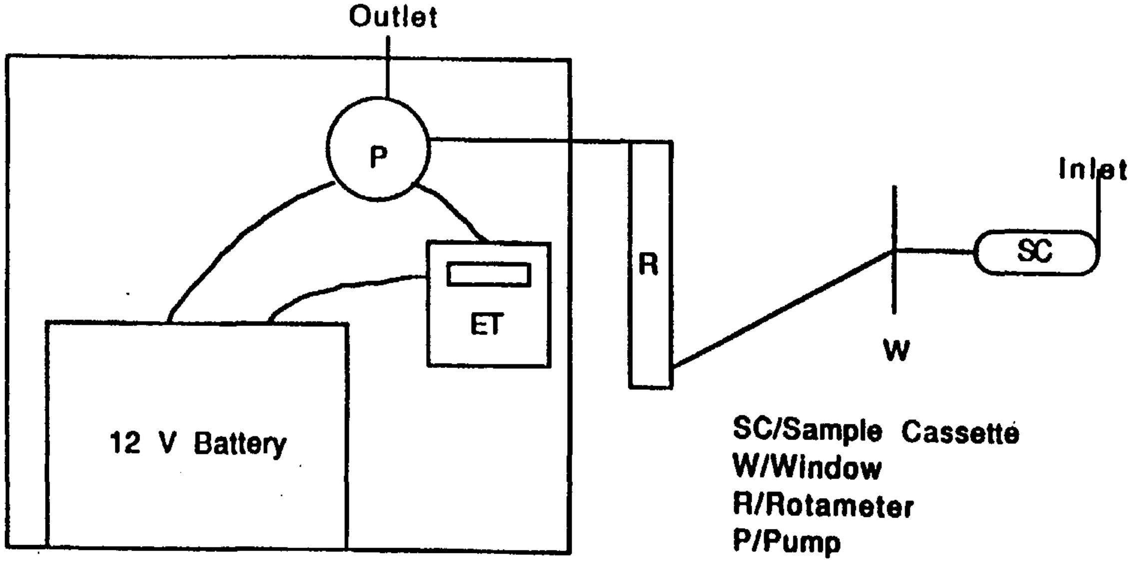


N
Sample Route
2/22/88
Sample #1
Homestake
Mine
Start
Long
Canyon
Creek


Start
Homestake Mine
Sample Route
2/22/88
Sample #2
Stop
N
ROAD CLASSIFICATION


N
Homestake Mine
Sample Route
2/22/88
Sample #3
Start
Stop

KNOXVILLE ASBESTOS SAMPLE TRAIN 2/22/88



SC/Sample Cassette
W/Window
R/Rotameter
P/Pump
ET/Elapsed Time-Meter

Note: All tubing used 1/4" O.D. Teflon, inlet to sample cassette 4" long

SAIC
Science Applications
International Corporation
An Employee-Owned Company

RECEIVED
APR 15 1988
LAKE COUNTY
AIR POLLUTION CONTROL

April 8, 1988

Mr. Ross Kauper
Lake County Air Quality Management District
883 Lakeport Blvd.
Lakeport, CA 95433

Reference: Purchase Order Number 88-011
SAIC Project Number 2-885-05-919-03

Dear Mr. Kauper:

Enclosed please find data reports for four air samples submitted to SAIC for asbestos analysis by transmission electron microscop/specifically, samples labeled Knoxville AB1 through 3 plus a blank.

If you have any questions please don not hesitate to call me at 619/535-7418 and thank you once again for your patience.

Sincerely,

Science Applications International Corporation

Nick P. Rottunda
Section Manager

4224 Campus Point Court, San Diego, California 92121 (619) 535-7462
Other SAIC Offices: Albuquerque, Chicago, Dayton, Denver, Huntsville, La Jolla, Los Angeles, McLean, Oak Ridge, Orlando, San Francisco, Tucson, and Washington, D.C.

FOR ARB USE ONLY

Chain of Custody Check Off Form

For samples going to RJ Lee Laboratory

1. Was the correct project # on side 1? [✓ YES] NO
2. Did submitter fill in their name? [✓ YES] NO
3. Were samples listed on side 1 in the sample box? Did the sample # and Log numbers match? [✓ YES] NO
4. Was the ARB portion of the block containing "the chain of custody seal intact information" filled out and signed? [✓ YES] NO
5. Was the ARB portion of the block containing "the chain of custody transfer information" filled out and signed? [✓ YES] NO

Witness Signature and Date Signed. 2-23-99

For samples returning from RJ Lee Laboratory

1. Was the RJ Lee Laboratory portion of the block containing "the chain of custody seal intact information" filled out and signed? YES NO
2. Was the RJ Lee Laboratory portion of the block containing "the chain of custody transfer information" filled out and signed? YES NO

Witness Signature and Date Signed. ____________________

APR 15 1988
LAKE COUNTY
AIR POLLUTION CONTROL

--- ASBESTOS SCREENING ANALYSIS ---
(Transmission Electron Microscopy)

Client Information: LAKE COUNTY AQMD
883 LAKEPORT BLVD
LAKEPORT CA 95453

Project Number: 2-885-05-919-03

Price/Sample: $300.00

SAMPLE #: KNOXVILLE 02
SAIC Log #: 88-063-005 Analysis Date: 4/7/88

SAMPLE DESCRIPTION: AIR SAMPLE ON 25 mm POLYCARBONATE FILTER IN STYRENE CASSETTE

SAMPLE VOLUME = 151.0 LITERS
FILTER AREA = 3.8 SQ.CM
FIELDS COUNTED AT 10000X = 7

DILUTION FACTOR = 1.0
FIELD AREA = 3295.0 SQ.UM
FIELDS COUNTED AT 5000X = 0

DETECTION LIMIT <5uM = 0.0913 FIBERS/CC
DETECTION LIMIT >5uM = 0.0000 FIBERS/CC

DATA SUMMARY

SIZE	CATAGORY	CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NON-ASBESTOS
<5.0uM	FIBERS COUNTED	117.0	(N.D.)	(N.D.)	1.0
	PERCENTAGE	99.2			0.8
	FIBERS/CC	10.7000	<0.0913	<0.0913	0.0913
>5.0uM	FIBERS COUNTED	1.0	(N.D.)	(N.D.)	(N.D.)
	PERCENTAGE				
	FIBERS/CC	0.0000	0.0000	0.0000	0.0000

TOTAL ASBESTOS FIBERS/CC = 10.7000

TOTAL NON-ASBESTOS FIBERS/CC = 0.0913

N.D. = Not Detected

ANALYST: DATE: 4/7/88

RECEIVED
APR 15 1988
LAKE COUNTY
AIR POLLUTION CONTROL

--- ASBESTOS SCREENING ANALYSIS ---
(Transmission Electron Microscopy)

Client Information:

LAKE COUNTY AQMD
883 LAKEPORT BLVD
LAKEPORT CA 95453

Project Number: 2-885-05-919-03

Price/Sample: $300.00

SAMPLE #: KNOXVILLE 03
SAIC Log #: 88-063-006 Analysis Date: 4/7/88

SAMPLE DESCRIPTION: AIR SAMPLE ON 25 mm POLYCARBONATE FILTER IN STYRENE CASSETTE

SAMPLE VOLUME = 195.2 LITERS
FILTER AREA = 3.8 SQ.CM
FIELDS COUNTED AT 10000X = 4

DILUTION FACTOR = 1.0
FIELD AREA = 3285.6 SQ.UM
FIELDS COUNTED AT 5000X = 0

DETECTION LIMIT <5uM = 0.1480 FIBERS/CC
DETECTION LIMIT >5uM = 0.0000 FIBERS/CC

DATA SUMMARY

SIZE	CATAGORY	CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NON-ASBESTOS
<5.0uM	FIBERS COUNTED	120.0	(N.D.)	(N.D.)	(N.D.)
	PERCENTAGE	100.0			
	FIBERS/CC	17.8000	<0.1480	<0.1480	<0.1480
>5.0uM	FIBERS COUNTED	2.0	(N.D.)	(N.D.)	(N.D.)
	PERCENTAGE				
	FIBERS/CC	0.0000	0.0000	0.0000	0.0000

TOTAL ASBESTOS FIBERS/CC = 17.8000

TOTAL NON-ASBESTOS FIBERS/CC = (N.D.)

N.D. = Not Detected

ANALYST:

DATE: 4/7/88

RECEIVED
APR 15 1988
LAKE COUNTY
AIR POLLUTION CONTROL

--- ASBESTOS SCREENING ANALYSIS ---
(Transmission Electron Microscopy)

Client Information:

LAKE COUNTY AQMD
883 LAKEPORT BLVD
LAKEPORT CA 95453

Project Number: 2-885-05-919-03

Price/Sample: $300.00

SAMPLE #: #4 (FIELD BLANK)
SAIC Log #: 88-063-007 Analysis Date: 4/7/88

SAMPLE DESCRIPTION: AIR SAMPLE ON 25 mm POLYCARBONATE FILTER IN STYRENE CASSETTE

SAMPLE VOLUME = 1.0 LITERS
FILTER AREA = 3.8 SQ.CM
FIELDS COUNTED AT 10000X = 10

DILUTION FACTOR = 1.0
FIELD AREA = 3285.0 SQ.UM
FIELDS COUNTED AT 5000X = 0

DETECTION LIMIT <5uM = 11.6000 FIBERS/CC
DETECTION LIMIT >5uM = 0.0000 FIBERS/CC

DATA SUMMARY

SIZE	CATAGORY	CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NON-ASBESTOS
<5.0uM	FIBERS COUNTED	(N.D.)	(N.D.)	(N.D.)	(N.D.)
	PERCENTAGE				
	FIBERS/CC	<11.6000	<11.6000	<11.6000	<11.6000
>5.0uM	FIBERS COUNTED	(N.D.)	(N.D.)	(N.D.)	(N.D.)
	PERCENTAGE				
	FIBERS/CC	0.0000	0.0000	0.0000	0.0000

TOTAL ASBESTOS FIBERS/CC = (N.D.)

TOTAL NON-ASBESTOS FIBERS/CC = (N.D.)

N.D. = Not Detected

ANALYST: ______________ DATE: 4/7/88

LAKE COUNTY AIR QUALITY
MANAGEMENT DISTRICT
— OFFICE AND LABORATORY —

883 Lakeport Blvd.
Lakeport, California 95453
Telephone: 707/263-7000
Burn Info.: 707/263-3121

ROBERT L. REYNOLDS
Air Pollution Control Officer
Noise Control Officer

November 24, 1987

Mr. Eric Johnson
Bureau of Land Management
555 Leslie St.
Ukiah, Ca. 95482

Dear Mr. Johnson:

RE: Regarding Knoxville Survey; Interim Asbestos Monitoring Report

Please find enclosed the referenced report and several attachments. The report covers the first monitoring effort only. As agreed, we have not attempted to interpret the data but we have provided a more recent document that could assist in such interpretation.

We will attempt to carry out additional sampling per your request if the weather allows. Ross is presently on vacation and will not return until Dec 7, 1987. If you concur, we can get together then to discuss any plans for further testing.

Should you have questions on the report please give me a call.

Sincerely,

Robert L Reynolds

Robert L. Reynolds

attachment: Interim Report

KNOXVILLE ASBESTOS SURVEY

LAKE COUNTY AIR QUALITY MANAGEMENT DISTRICT

INTERIM REPORT
November 27, 1987

DESCRIPTION & BACKGROUND

Sampling for asbestos from road generated dust was conducted by District and BLM personnel on September 29, 1987 (Eric Johnson, BLM; Ross Kauper and Lowell Grant, LCAQMD). This was performed at BLM's request to gather technical data to be considered as part of a NEPA document considering the area for an Off Road Vehicle (ORV) area. Three sites identified as AB-1, AB-2 and AB-3 as shown on the attached map (Figure 1) were selected for monitoring of airborne asbestos fiber levels coincident with simulated ORV use near the sites. A Meteorology Research Inc. mechanical weather station was also installed and operated at site AB-2 to record wind speed, direction and temperature during the sampling period.

The exact monitoring locations were selected by BLM personnel after consultation with the District on site, prior to initiating the monitoring. Sites were selected largely on the basis of the observed extent of serpentine rock type outcropping on road cuts. The sites were spaced sufficiently distant and were different in extent of serpentine outcroppings to represent a range of the more general area conditions.

SAMPLING METHOD

The samplers were fabricated by the District, set up and operated at the respective sites to achieve a flow rate of 4.0 liters per minute (standard conditions). The start time and elapsed sample times were recorded to calculate the total sample volume. Volumes were corrected from standard pressure and temperature to the actual field conditions. Science Application International Corp., (SAIC) was supplied with these volumes for the calculation of the asbestos concentration results. The sampling media was prepared by SAIC and provided the District whom was responsible for collection of samples. The inlet to the sample filter casettes was located at an elevation of 5 feet above ground level to simulate the respiratory zone of humans. Copies of the field test report, volume calculations and photographs of the sampling sites are included in Attachment 1. [redacted] the procedure utilized. On mutual decision, the location of AB-2 was moved to the opposite side of the roadway after the first hour of sampling to account for the wind shift observed at that location, no other deviations in the program occurred during the sampling.

Sample sites were established so that vehicular traffic generated dust would be upwind and flow into the sampling stations. At sites AB-2 and AB-3 five drive-bys, at 20 miles per hour were made by a Quad Runner ORV (1), 4x4 Pickup Truck (1), GMC 1-ton Van (1) and a 1/2 ton Nissan Pickup (2). At site AB-1 a total of seven (7) vehicle drive-bys at 20 miles per hour were made by a Quad Runner ORV (2), 4x4 Pickup Truck (1), GMC 1-ton Van (2) and a 1/2 ton Nissan Pickup (2). The number of drive-bys is indicated in parenthesis. The sampling apparatus was located at an estimated six (6) feet from the drive-by path.

The 25 mm filter casettes utilized for sample collection were prepared and provided by SAIC and delivered to the District for sample collection in the field. The collected samples and a blank filter were returned to the laboratory for transmission electron microscope analysis. The District deployed one filter in the field during the test period as a control blank. This filter received handling as a regular sample and was also returned to the lab for background analysis.

RESULTS

The hourly averages for the meteorological measurements made at site AB-2 coincident with sample collection are presented below in table I.

TABLE I
Meterological Monitoring (Site AB-2)

Time of Day	Dir- Degrees TN	Wind MPH	Temp F
10:00 (PDT)	20	4	92
11:00 (PDT)	100	3	97
12:00 (PDT)	100	3	99
13:00 (PDT)	90	4	101

The results of the field and blank analysis for total asbestos and non asbestos fibers are presented in Attachment 3 and summarized below in table II.

TABLE II

Sample	Cubic Meters	Total Minutes	Vehicle Drive-bys	Non-asbestos Fibers/cc	Asbestos Fibers/cc
AB-1	0.9227	255	7	0.0416	0.1453
AB-2	0.8923	246	5	0.0197	0.0513
AB-3	0.751345	207	5	Not Detected	0.0632
Blank	0	n a	n a	Not Detected	Not Detected

Field conditions during the test run were conducive to dust generation, no reportable rain fall had been recorded at the adjacent Homestake Mining Company site during the recent monitoring beginning July 1, 1987. Road conditions were dry. Temperatures were recorded between 90 and 101 degrees Farenheit during the monitoring period. Winds were low and not expected nor observed to generate dust. Conclusions are not offered, but a Dept. of Health Services document dated January1986 and entitled "Health Effects of Asbestos" is attached for the readers consideration.

Submitted By:

Ross L. Kauper
Ross L. Kauper

11/24/87

Attachments:
- 3 Polaroid pictures
- Map (figure 1)
- 3 field test reports
- SAIC Analysis Report
- DHS document on "Health Effects of Asbestos"

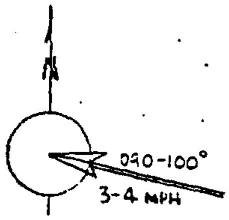
RLK/RLR

KNOXVILLE AB#1 AB-1
9/29/87 0940 PST R. KAUPER

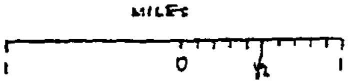
KNOXVILLE #AB2 + MET STATION
9/29/87 1010 PST AB-2

KNOXVILLE AB#3 AB-3
1040 PST
9/29/87

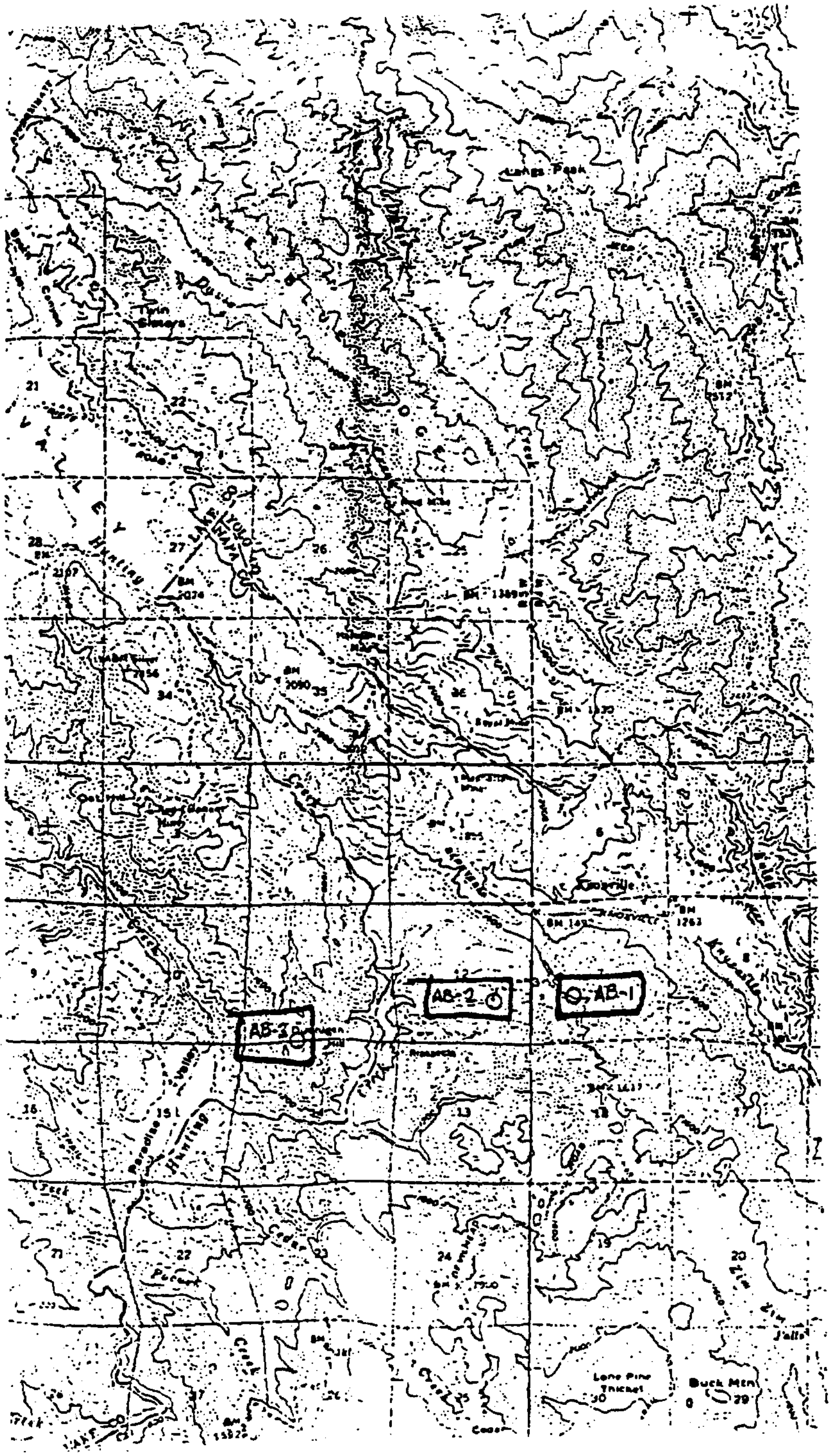
HR	WD	WS	T (°F)
10	090	4	92
11	100	3	97
12	100	3	99
13	090	4	101



WIND DATA AT SITE AB-2
11:00 - 13:00 PST
SEPT 29, 1987



Knoxville Asbestos
Monitoring
9/29/87



LAKE COUNTY AIR POLLUTION CONTROL DISTRICT

FIELD TEST REPORT

Date of Test: 9/29/87

Location of Test: Knoxville Site AB-1

Substance Tested: ASBESTOS

Type of Test: 25mm filter - Transmission Electron Microscopy

BP = 28.45
TA = 35°C

Sampling: Time 0946 PST ~~1400 PST~~ ET 194.6 198.85 **Rate:** START 4.0 LPM END 4.0 LPM

Color - Grade - Range

Range of Concentration

Calculations:

$$\frac{\begin{matrix}198.85\\194.60\end{matrix}}{}(4.25\ HR)\left(60\ \frac{MIN}{HR}\right) = 255\ MIN \times 4.0\ LPM = \frac{1020\ Liters}{1000\ L/m^3}$$

$= 1.02\ m^3$

$\times .9045$ TP corr

$= .922682\ m^3$

T/P corr

$$\frac{28.45}{29.92} \times \frac{293}{273+35} = (.9508)(.9513) = .9045$$

Comments: SEE ATTACHED MAP

Signature

9/30/87
Date

Reviewed By

Date

1-Atmosphere & 20°C

LAKE COUNTY AIR POLLUTION CONTROL DISTRICT

FIELD TEST REPORT

Date of Test: 9/29/87

Location of Test: Knoxville Site AB-2

Substance Tested: Asbestos

Type of Test: 25mm Filter, Transmission Electron Microscope

BP = 28.52"Hg

T_A = 35°C

Sampling: Time 1012 PST / 1345 PST ET 211.6 / 215.7 Rate: START 4.0 LPM / END 4.0 LPM

Color - Grade - Range

Range of Concentration

Calculations:

$$\begin{array}{r} 215.7 \\ -\,211.6 \\ \hline \end{array}$$

$$(4.1\ HR)\left(60\ \frac{MIN}{HR}\right) = 246\ MIN \times 4.0\ LPM = \frac{984\ Liters}{1000\ \ell/m^3}$$

$$= .984\ m^3$$

$$\times\ .90678$$

$$= .892276\ M^3$$

$$\left(\frac{28.52}{29.92}\right) = .9532 \cdot \frac{293}{273+35} = .90678$$

Comments:

Ross Kemper

Signature

9/30/87

Date

Reviewed By

Date

LAKE COUNTY AIR POLLUTION CONTROL DISTRICT

FIELD TEST REPORT

Date of Test: 9/29/87

Location of Test: Knoxville Site AB #3

Substance Tested: ASBESTOS

Type of Test: 25 mm Filter, Transmission Electron Microscope

$P_B = 28.54$ " Hg
$T_A = 35°C$

Sampling: Time START 1040 PST
END 1207 PST

Rate: START 4.0 LPM
END 4.0 LPM

Color - Grade - Range

Range of Concentration

Calculations: $207 \text{ min} \times 4.0 \text{ lpm} = \frac{828 \ell}{1000 \ell/m^3} = .828 \ m^3$

$$\frac{28.54}{29.92} = .95377 \times \frac{293}{273+35} = .90742(.828 m^3) = .751345 \ m^3$$

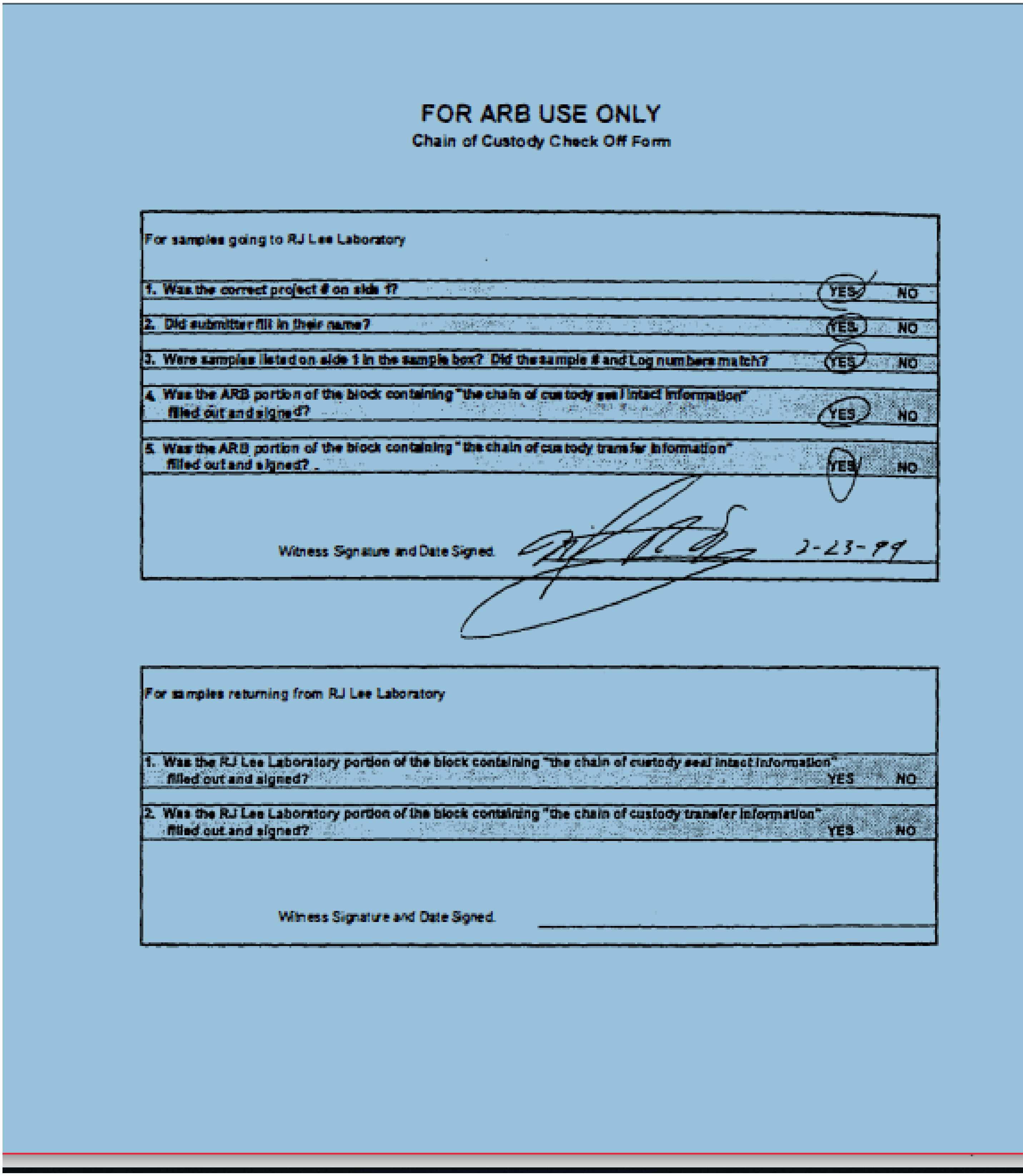
Comments:

R. Kemper
Signature

9/30/87
Date

Reviewed By

Date



FOR ARB USE ONLY

Chain of Custody Check Off Form

For samples going to RJ Lee Laboratory

1. Was the correct project # on side 1? [✓ YES] NO
2. Did submitter fill in their name? [✓ YES] NO
3. Were samples listed on side 1 in the sample box? Did the sample # and Log numbers match? [✓ YES] NO
4. Was the ARB portion of the block containing "the chain of custody seal intact information" filled out and signed? [✓ YES] NO
5. Was the ARB portion of the block containing "the chain of custody transfer information" filled out and signed? [✓ YES] NO

Witness Signature and Date Signed. 2-23-99

For samples returning from RJ Lee Laboratory

1. Was the RJ Lee Laboratory portion of the block containing "the chain of custody seal intact information" filled out and signed? YES NO
2. Was the RJ Lee Laboratory portion of the block containing "the chain of custody transfer information" filled out and signed? YES NO

Witness Signature and Date Signed. ____________________

SAIC
Science Applications International Corporation

OCT 14 1987

13 October 1987

Mr. Ross Kauper
Lake County Air Quality Management District
883 Lakeport Blvd.
Lakeport Ca. 95453

Reference: Purchase order number 88-010
SAIC Project number 2-885-02-638-00

Dear Mr. Kauper,

Enclosed please find data reports for four air samples submitted to SAIC for asbestos analysis by transmission electron microscopy. Specifically, samples AB-1 TEM, AB-2 TEM, AB-3 TEM, AB-4 TEM are included. Invoicing follows under separate cover.

Please do not hesitate to call me at 619/535-7416 if you have any questions.

Sincerely,

Spencer L. Frankel
Microscopy Labratory Manager

Encls.

Division of Applied Environmental Sciences. 476 Prospect Street, La Jolla, California 92037 (619) 456-7462
Other SAIC Offices: Albuquerque, Chicago, Dayton, Denver, Huntsville, Los Angeles, Oak Ridge, Orlando, San Diego, San Francisco, Tucson and Washington DC

--- ASBESTOS SCREENING ANALYSIS ---
(Transmission Electron Microscopy)

Client Information:

LAKE COUNTY AQMD
883 LAKEPORT BLVD.
LAKEPORT CA 95453

Project Number: 2-885-02-638-00

Price/Sample: $300.00

SAMPLE #: AB-1
SAIC Log #: 87286001

Analysis Date: 10\7\87

SAMPLE DESCRIPTION: AIR SAMPLE ON 25 mm POLYCARBONATE FILTER IN STYRENE CASSETTE

SAMPLE VOLUME = 923.0 LITERS
FILTER AREA = 3.8 SQ.CM
FIELDS COUNTED AT 10000X = 20

DILUTION FACTOR = 1.0
FIELD AREA = 3600.0 SQ.UM
FIELDS COUNTED AT 5000X = 60

DETECTION LIMIT <5uM = 0.0057 FIBERS/CC
DETECTION LIMIT >5uM = 0.0019 FIBERS/CC

DATA SUMMARY

SIZE	CATAGORY	CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NON-ASBESTOS
<5.0uM	FIBERS COUNTED	23.0	1.0	(N.D.)	6.0
	PERCENTAGE	70.4	3.1		18.4
	FIBERS/CC	0.1320	0.0057	<0.0057	0.0343
>5.0uM	FIBERS COUNTED	3.0	1.0	1.0	3.0
	PERCENTAGE	3.1	1.0	1.0	3.1
	FIBERS/CC	0.0057	0.0019	0.0019	0.0057

TOTAL ASBESTOS FIBERS/CC = 0.1453

TOTAL NON-ASBESTOS FIBERS/CC = 0.0419

N.D. = Not Detected

ANALYST: ____________________ DATE: ______________

--- ASBESTOS SCREENING ANALYSIS ---
(Transmission Electron Microscopy)

Client Information: LAKE COUNTY AQMD
883 LAKEPORT BLVD.
LAKEPORT CA 95453

Project Number: 2-885-02-638-00

Price/Sample: $300.00

SAMPLE #: AB-2
SAIC Log #: 87286002 Analysis Date: 10\8\87

SAMPLE DESCRIPTION: AIR SAMPLE ON 25 mm POLYCARBONATE FILTER IN STYRENE CASSETTE

SAMPLE VOLUME = 892.0 LITERS
FILTER AREA = 3.8 SQ.CM
FIELDS COUNTED AT 10000X = 20

DILUTION FACTOR = 1.0
FIELD AREA = 3600.0 SQ.UM
FIELDS COUNTED AT 5000X = 60

DETECTION LIMIT <5uM = 0.0059 FIBERS/CC
DETECTION LIMIT >5uM = 0.0020 FIBERS/CC

DATA SUMMARY

SIZE	CATAGORY	CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NON-ASBESTOS
<5.0uM	FIBERS COUNTED	7.0	(N.D.)	(N.D.)	2.0
	PERCENTAGE	58.3			16.7
	FIBERS/CC	0.0414	<0.0059	<0.0059	0.0118
>5.0uM	FIBERS COUNTED	5.0	(N.D.)	(N.D.)	4.0
	PERCENTAGE	13.9			11.1
	FIBERS/CC	0.0099	<0.0020	<0.0020	0.0079

TOTAL ASBESTOS FIBERS/CC = 0.0513

TOTAL NON-ASBESTOS FIBERS/CC = 0.0197

N.D. = Not Detected

ANALYST: ______________________ DATE: ______________

--- ASBESTOS SCREENING ANALYSIS ---
(Transmission Electron Microscopy)

Client Information:

LAKE COUNTY AQMD
883 LAKEPORT BLVD.
LAKEPORT CA 95453

Project Number: 2-885-02-638-00

Price/Sample: $300.00

SAMPLE #: AB-3
SAIC Log #: 87286003

Analysis Date: 10\8\87

SAMPLE DESCRIPTION: AIR SAMPLE ON 25 mm POLYCARBONATE FILTER IN STYRENE CASSETTE

SAMPLE VOLUME = 751.0 LITERS
FILTER AREA = 3.8 SQ.CM
FIELDS COUNTED AT 10000X = 20

DILUTION FACTOR = 1.0
FIELD AREA = 3600.0 SQ.UM
FIELDS COUNTED AT 5000X = 60

DETECTION LIMIT <5uM = 0.0070 FIBERS/CC
DETECTION LIMIT >5uM = 0.0023 FIBERS/CC

DATA SUMMARY

SIZE	CATAGORY	CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NON-ASBESTOS
<5.0uM	FIBERS COUNTED	8.0	(N.D.)	(N.D.)	(N.D.)
	PERCENTAGE	88.9			
	FIBERS/CC	0.0562	<0.0070	<0.0070	<0.0070
>5.0uM	FIBERS COUNTED	3.0	(N.D.)	(N.D.)	(N.D.)
	PERCENTAGE	11.1			
	FIBERS/CC	0.0070	<0.0023	<0.0023	<0.0023

TOTAL ASBESTOS FIBERS/CC = 0.0632

TOTAL NON-ASBESTOS FIBERS/CC = (N.D.)

N.D. = Not Detected

ANALYST: ____________________ DATE: ______________

--- ASBESTOS SCREENING ANALYSIS ---
(Transmission Electron Microscopy)

Client Information: LAKE COUNTY AQMD
883 LAKEPORT BLVD.
LAKEPORT CA 95453

Project Number: 2-885-02-638-00

Price/Sample: $300.00

SAMPLE #: AB-4
SAIC Log #: 87286004 Analysis Date: 10\8\87

SAMPLE DESCRIPTION: AIR SAMPLE ON 25 mm POLYCARBONATE FILTER IN STYRENE CASSETTE

SAMPLE VOLUME = 1.0 LITERS
FILTER AREA = 3.8 SQ.CM
FIELDS COUNTED AT 10000X = 20

DILUTION FACTOR = 1.0
FIELD AREA = 3600.0 SQ.UM
FIELDS COUNTED AT 5000X = 60

DETECTION LIMIT <5uM = 5.2800 FIBERS/CC
DETECTION LIMIT >5uM = 1.7593 FIBERS/CC

DATA SUMMARY

SIZE	CATAGORY	CHRYSOTILE	AMPHIBOLE	AMBIGUOUS	NON-ASBESTOS
<5.0uM	FIBERS COUNTED	(N.D.)	(N.D.)	(N.D.)	(N.D.)
	PERCENTAGE				
	FIBERS/CC	<5.2800	<5.2800	<5.2800	<5.2800
>5.0uM	FIBERS COUNTED	(N.D.)	(N.D.)	(N.D.)	(N.D.)
	PERCENTAGE				
	FIBERS/CC	<1.7593	<1.7593	<1.7593	<1.7593

TOTAL ASBESTOS FIBERS/CC = (N.D.)

TOTAL NON-ASBESTOS FIBERS/CC = (N.D.)

N.D. = Not Detected

ANALYST: ____________________ DATE: ______________

Air Resources Board
Jamestown Mine Road Study

State of California

MEMORANDUM

To : Peter Ouchida, Manager
Testing Section

Date : February 22, 1989

Subject : Results of Asbestos Monitoring Conducted Around Jamestown During February 6-8, 1989

James McCormack JEM
Monitoring and Laboratory Division
From : Air Resources Board

During of the week of February 6, 1989, the Air Resources Board (ARB) staff conducted a monitoring program to determine the ambient concentration of asbestos at ten sites within the vicinity of Jamestown in Tuolumne County. The results of the monitoring program are shown in Table I. These results were presented to Jerry Benincasa, Tuoluome County Air Pollution Control Officer, verbally over the phone on February 10 and February 16.

A test protocol describing the sampling equipment, sampling methodologies, and details of the monitoring program is presented in Attachment I. Prior to conducting the monitoring, the staff discussed the protocol at a February 6, 1989, meeting with Jerry Benincasa and representatives from Sonora Mining Corporation and Woods Creek Quarry (attendees of the meeting are shown in Table II). Based on inputs obtained at the meeting, a final test protocol was developed and agreed upon by all parties.

Figure 1 is a map of the sampling area and identifies the locations of each ARB sampling site, ARB meteorological station sites, and Sonora Mining Corporation's (SMC) meteorological station. The monitors were set-up at two sampling sites within the Hurst and SMC properties and one monitor was set up within the Woods Creek Quarry. These sampling sites are identified as #1, #2, #3, #4, and #5 in Figure 1 and correspond to the same sites used in the March 1988 ARB monitoring program. Four sampling sites, #7, #8, #9, and #10 were set up to determine the affects of SMC blasting operations. Sampling site #6 was considered a background sampling site.

Table I

Results of Sampling in the Jamestown Area of Tuolumne County

sample		sampling dates				ambient concentrations	minimum& detection limits
		start		end			
#	Location	date	time	date	time	Structures/m^3	Structures/m^3
1A	SMC PIT^	2/6/89	1715	2/7/89	1715	ND	<2000
1B	SMC PIT	2/7/89	1720	2/8/89	1717	ND	<2000
2A	SMC PIT^	2/6/89	1735	2/7/89	1735	4000	NA
2B	SMC PIT	2/7/89	1738	2/8/89	1720	6000	NA
3A	WC QUARRY Rd^	2/6/89	1800	2/7/89	1815	5900	NA
3B	WC QUARRY Rd	2/7/89	1816	2/8/89	1630	2100	NA
4A	HURST LAWN^	2/6/89	1815	2/7/89	1839	ND	<1900
4B	HURST LAWN	2/7/89	1840	2/8/89	1620	ND	<2200
5A	HURST HILL ^	2/6/89	1835	2/7/89	1834	15800	NA
5B	HURST HILL	2/7/89	1835	2/8/89	1618	ND	<2200
6A	SMC SITE #35+^	2/6/89	1710	2/7/89	1705	ND	<2100
6B	SMC SITE #35+	2/7/89	1706	2/8/89	1654	ND	<2100
8	SMC READY LINE^	2/8/89	0929	2/8/89	1024	ND	<51800@
7	SMC READY LINE	2/7/89	1744	2/8/89	1737	ND	<2000
10	SMC STOCKPILE*^	2/8/89	0925	2/8/89	1015	ND	<57000@
9	SMC STOCKPILE*	2/7/89	1755	2/8/89	1742	2000	NA
11	FIELD BLANK	2/8/89	0800	2/8/89	0800	ND	<2000
M1	SMC PIT	2/7/89	1534	2/7/89	1944	6200	NA

&	minimum detection limits only reported when no structures are detected
+	background sampler
*	sample of blasting fallout
@	high minimum detection limit due to low sample volume
^	intermittent snow showers afternoon of 2/8/89
ND	none detected
NA	not applicable

FIGURE 1
Sonora Sampling Area
Containing The Sampling and Meteorological Sites

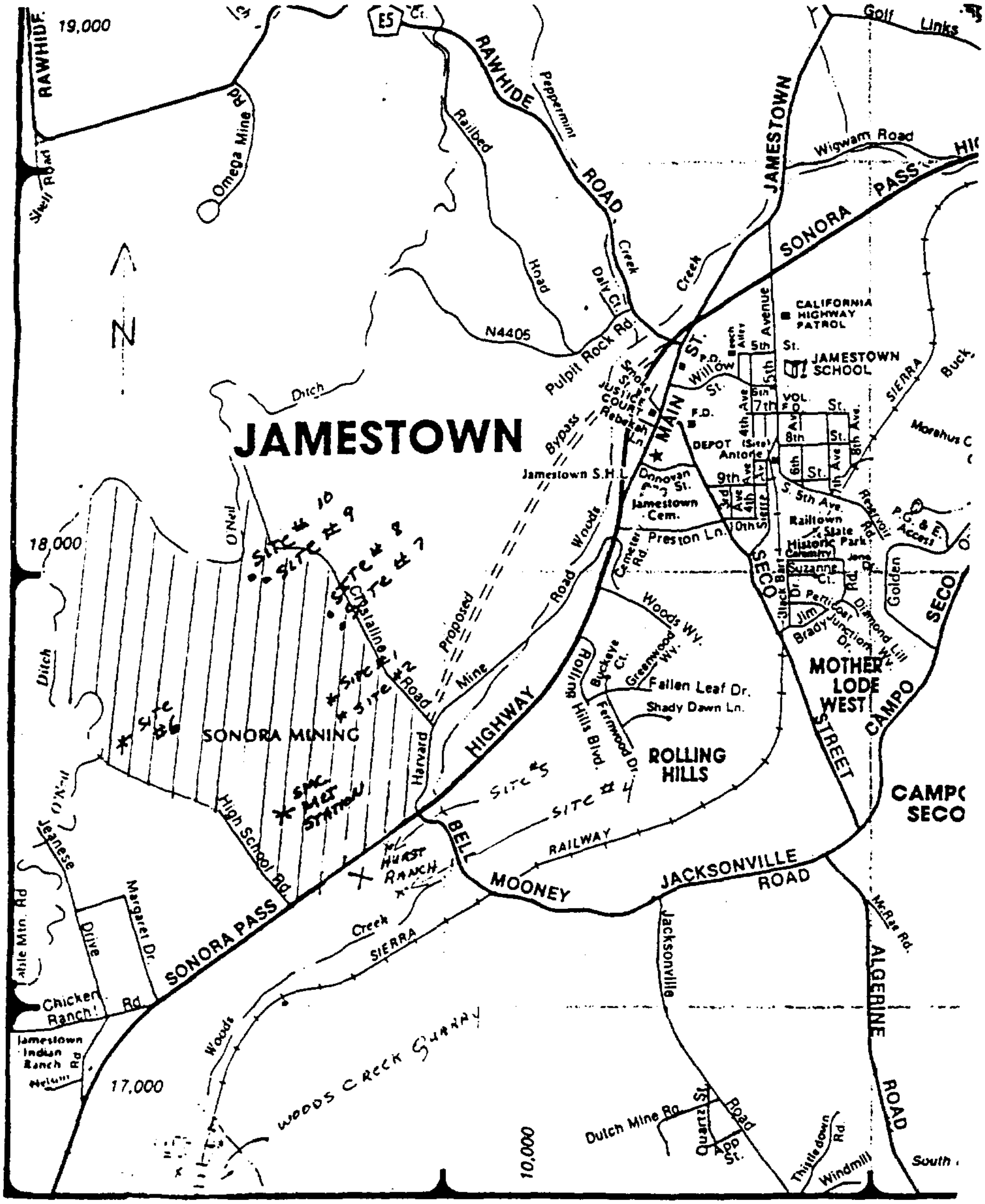


Table II

Attendees of Meeting Reviewing Sampling Protocol

name	affiliation
Jerry Benincasa	Tuolumne County APCD
Mike Waugh	Tuolumne County APCD
George Lew	ARB
Peter Ouchida	ARB
Jeff Lee	ARB
James McCormack	ARB
David Skolasinski	Sonora Mining Corp.
David Lee	Sonora Mining Corp.
John Pradenas	Sonora Mining Corp.
Bud Hatler	Woods Creek Rock Quarry

A total of 18 samples were collected from ten sampling sites over a two consecutive twenty-four period beginning on February 6. One additional sample was taken, over a four hour period, using a "monocot" ambient air samplers at site #2. This type of sampler was used in the 1988 ARB monitoring program. Two consecutive twenty-four samples were collected at a location called background (#6).

In an attempt to determine the asbestos concentration during the blasting at SMC, four samplers were setup at two locations downwind (sites #7, #8, #9, and #10) of the blast area. Sites #7 and #8 were adjacent to each other and northeast of the blast area while sites #9 and #10 were adjacent to each other and due north of the blast area. Samples at sites #7 and #9 were taken over a twenty-four period while samples at sites #8 and #10 were taken during a one hour interval starting before the blast. Due to the wind direction occurring during the blast, samples taken at sites #7 and #8 were not in the "drift" pattern of the blast plume and sites #9 and #10 were marginaly in the blast plume.

The last sample was a field blank. The field blank is a sampling cassette that is uncapped, placed in the monitoring equipment, removed and capped. The field blank is used to determine the effects of handling and contamination.

The wind data from the ARB meteorological stations are summarized in Table III. A snow shower occurred during a four hour period on the afternoon of February 8, 1989. The effect of the snow shower on the asbestos concentration is unknown.

Attachments

TABLE III

Wind Speed and Direction

site	sampler location	wind direction	wind speed mph	time frame
6	SMC Site #35	SE to SW	1.5 - 4	All the Time
5	HURST Ranch Hill	SE	2 - 2.5	9:00am to 4:00pm
		N to NW	2 - 2.5	Rest of Time
1	SMC Pit	SE to SW	1.5 - 4	All the Time

Attachment I

EVALUATION TEST PROCOTOL

(AVAILABLE UPON REQUEST)

United States Environmental Protection Agency
Road Study

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
215 Fremont Street
San Francisco, Ca. 94105

ENVIRONMENTAL ASBESTOS ROADS STUDY
FIELD WORK REPORT

Lauren Volpini
Emergency Response Section
Field Operations Branch
Toxics and Waste Management Division

MARCH 1988

FINAL

TABLE OF CONTENTS

ACKNOWLEDGMENTS

A special thank you and note of appreciation to my Supervisor, P.T. Brubaker, Chief of the Emergency Response Section (ERS).

At the close of this Study, I am leaving the ERS for a new position - hopefully wiser, certainly older and deeply appreciative for having worked with a man who has given me selfless opportunity to grow and learn over the past 5+ years. His kindness and integrity, his creative non-bureaucratic approach, his fine intellect and his sound advice and guidance have not gone unrecognized by those who count most - his staff.

Lauren Volpini
US EPA Region 9
San Francisco January 1988

I. INTRODUCTION AND BACKGROUND

California's state rock, serpentine, often contains naturally occuring asbestos fibers. This rock has been, and continues to be quarried, crushed and applied as surface aggregate on unpaved roads. Via vehicle travel, asbestos fibers are liberated into the air, potentially exposing vehicle occupants and residents to unsafe levels of asbestos. Over the past few years, EPA Region 9 has carried out three Superfund emergency response actions on such roads - in Garden Valley, CA, in Copperopolis, CA and at the Superfund National Priority List site in Alviso, CA.

Upon better understanding of the potential magnitude of the problem in our Region, we decided to find a method which would more accurately and cost-effectively assess a site's potential asbestos levels and health risks.

We began by developing a "model" designed to estimate ambient air concentrations of asbestos fibers from the concentrations found in bulk road samples. Then, we designed a study to field test the model's validity, involving traffic simulation, air and soil sample collection and meteorological monitoring. At the end of the 1987 dry season during October, we conducted the study at a pre-selected test site in Amador County, CA. After analyzing the the air and soil samples via combinations of polarized light microscopy, phase contrast microscopy/dispersion staining and transmission electron microscopy, we hired an independent laboratory to perform a quality assurance review of the analyses. The data and laboratory reports were further reviewed by a contract quality assurance officer prior to final scrutiny by the Quality Assurance Management Section, EPA Region 9. Because serious quality assurance and quality control measures were integral to all aspects of each Study component, the final data summaries presented in this document are valid for all purposes.

Our efforts were aided by EPA's Office of Air Quality, Planning and Standards in Research Triangle Park, N.C. and Environmental Response Team in Edison, N.J., the National Ocean and Atmospheric Agency's Hazardous Materials Office in Seattle, WA and air quality specialists under our emergency response technical assistance contract.

This Field Study Report discusses the implementation of the US EPA Region 9 Environmental Asbestos Roads Study: Sample Plan (US EPA, November, 1987). Within, you will find an overview of the Study's field work phase with summaries of the sampling methodology and rationale, laboratory services and sample analysis.

A dBase III data management system is now in place, storing all meteorological and sample data. A summary of this data is included in Section VI of this report and contains several graphs and tables which are offered to aquaint the reader with a few apparent summarizations of the enormous amount of data generated and collected.

To implement the specifics of the Sample Plan, the Study Team collected representative air, soil and meteorological data which now may be used to verify the "Copeland Model" and/or to provide data for application to another model. It is hoped that the model may serve to help estimate potential airborne asbestos fiber concentrations from roads surfaced with asbestos containing serpentinite rock. Because this report is best understood in the context of the Sample Plan, it is recommended that the reader review the Plan prior to the reading this report.

Now that we have the Study data, our next steps are to compare the predicted values of the Copeland Model with the values measured in the Study's sampling effort. This comparison is expected to help us verify or nullify the model. If it is determined that we may use the Copeland Model with confidence, we would then have the basis for a new method to help us quickly and cost effectively determine whether a particular site poses unacceptable public health risks and whether or not a federal response action is warranted. If it is determined that the Copeland Model as expressed has not been verified by the Study, we hope to apply the study data to additional statistical software, to other models, or have it serve as a basis for, or input to, future studies.

The reader's interest in accessing our data base or receiving specific reports is encouraged as are his comments and questions on the Study design and implementation.

A. Field Work Dates and List of Study Team Members

The field work phase of the Study was conducted from Monday, October 12, 1987 through Tuesday, October 20, 1987. The Study Team was comprised of the following members:

Lauren Volpini - Project Manager
  Emergency Response Section, US EPA Region 9
Phil Campagna - Technical Advisor
  Environmental Response Team (ERT), US EPA, Edison, N.J.
Sella Burchette - Technical Advisor, ERT (formally with Weston)
Debra Simeneck-Beatty - Meteorological Advisor
  Hazardous Materials Section, National Oceanic & Atmospheric Agency (NOAA) Seattle, WA.
Renee Cohen - Post field work technical assistance, REAC (Weston - EPA Contractor)
Ecology & Environment, Inc. (EPA Contractors)
  Gary Floyd - Assistant Team Leader, TAT
  Tom Ferrera - Air Quality Technical Advisor (Corporate)
  Don Woody - Technical Assistance, TAT
  Mary Sapp - Technical Assistance, TAT
  Pat Chadwick - Post field work data management
  Cindy Jones - Post field work technical assistance

II. THE STUDY SITE

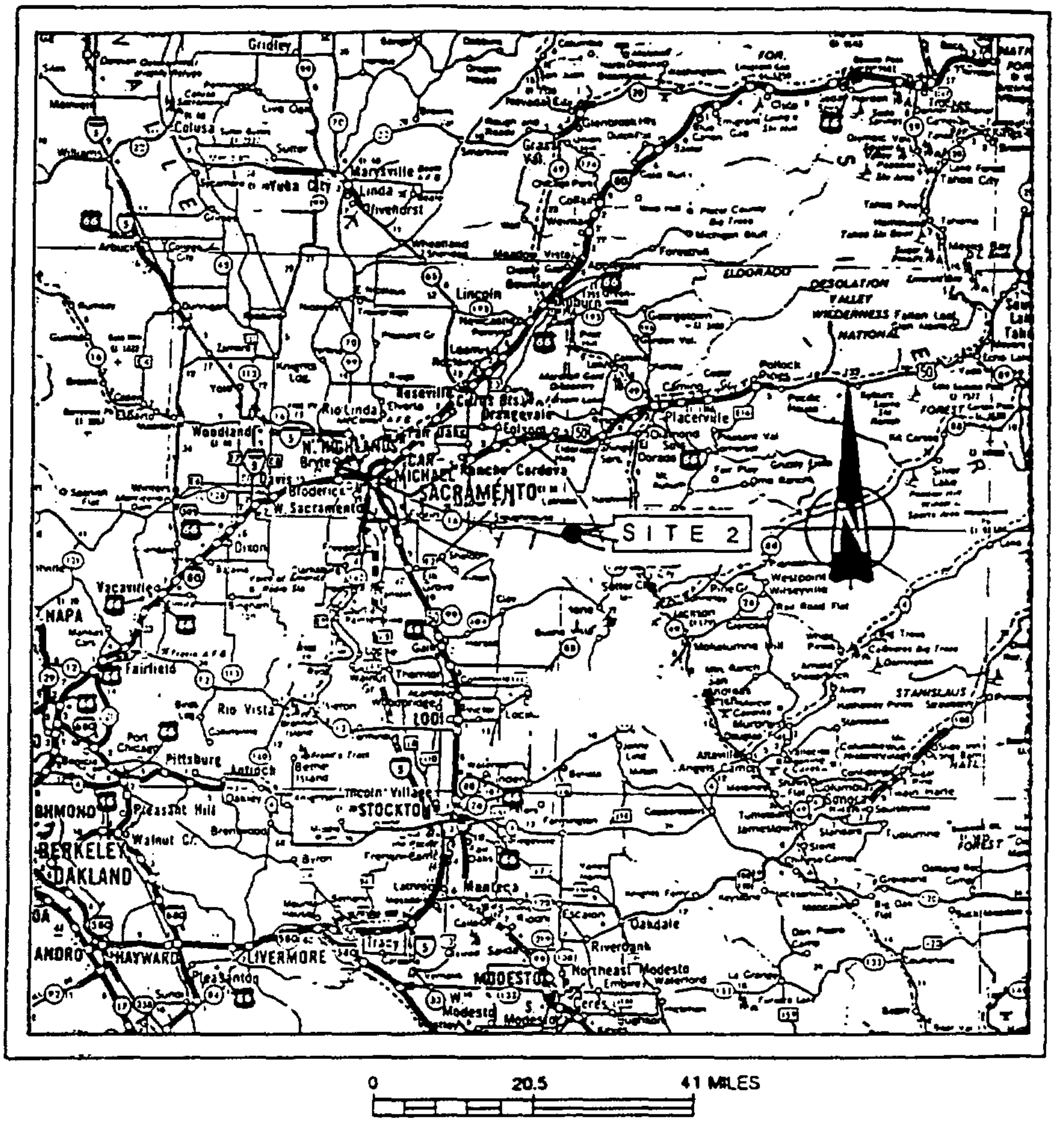
Initially, the field work was going to involve two distinct study sites in the Mother Lode Region of California, with three days of sampling devoted to each site. For a detailed explanation of both test sites and how they were selected, please refer to the Environmental Asbestos Roads Study Sample Plan (US EPA November, 1987).

Site 1 is located in Calaveras County, approximately 2 miles from the County Seat of San Andreas, CA. Site 2 is located in Amador County, approximately 18 miles from the County Seat of Jackson, CA. (see Map 1 Site Location Map). The Study Team decided to begin at Site 2 because of its ideally isolated location and close proximity to water and power. While the field work was in progress at Site 2 however, a few members of the Study Team re-visited Site 1 to reassess its topographical and meteorological characteristics. As a result of this assessment, it was determined that Site 1 would not be as conducive to the Study objectives as the relative merit of remaining at Site 2 and continuing the sampling effort there. This decision was based on Site 1's topographical influences - boulders along the downwind edge of the test road, a steep hill west of the proposed sampling locations, road grade, steep drop off the northeast area of interest - and, meteorological characteristics - winds not generally perpendicular to the test road. Additionally, Site 1 is so clearly visible from the major highway of the area, Highway 49, that to protect the delicate and expensive sampling equipment, overnight security would have been necessary and yet not readily available. To remain at Site 2 and sample for the entire 6 day period was deemed most sensible.

Due to the short planning phase of the Study, some factors were not considered, such as, long term site specific meteorological data, roads with varying grades, varying concentrations of asbestos, nighttime sampling, and various weights and speeds of test vehicles.

A. The Test Area

Upon arrival at the Study Site, the area was closely scrutinized to find the optimum 100' test section. Parameters for optimum conditions included: relatively level road and its immediate surrounds (lateral extent approximately 300'), minimum foliage in the area (i.e., trees and shrubs) and the road oriented such that the predominent wind direction would be perpendicular to the road. 200' of road at either end of the 100' test section was also required as an area where the test car could "coast" as opposed to "braking." This added a buffer zone so that potential asbestos emmissions from brake linings would be less likely to contribute to the airborne asbestos count in the immediate test area and to avoid the potential concentration of particulates and asbestos released from the road surface as a result of the force of "braking". In fact, the only optimum test condition unable to be met was to have a 300' downwind station. Topographically, the



MAP 1
ENVIRONMENTAL ASBESTOS STUDY
SITE LOCATION MAP

MOTHER LODE REGION, CALIFORNIA

test site (necessarily level for the sampling stations), allowed for a maximum downwind station of only 100'. At approximately 100', the vegetation became too dense to locate additional air sampling stations.

Upon selection of the specific 100' test section, a survey was made to correctly orient all pertinent equipment (i.e., air sampling stations, meteorological station, generators, etc.). This began by taking a bearing of the road itself, which would orient all equipment and air sampling points perpendicular to the road. All station locations were surveyed and staked on the ground at pre-determined distances from the road. A "No Braking" area, a "Hot-Line", a Decontamination Area (Decon), the Study Team Command Post and the placement of the outdoor latrines were also designated (refer to Map 2).

B. Soil Sampling*

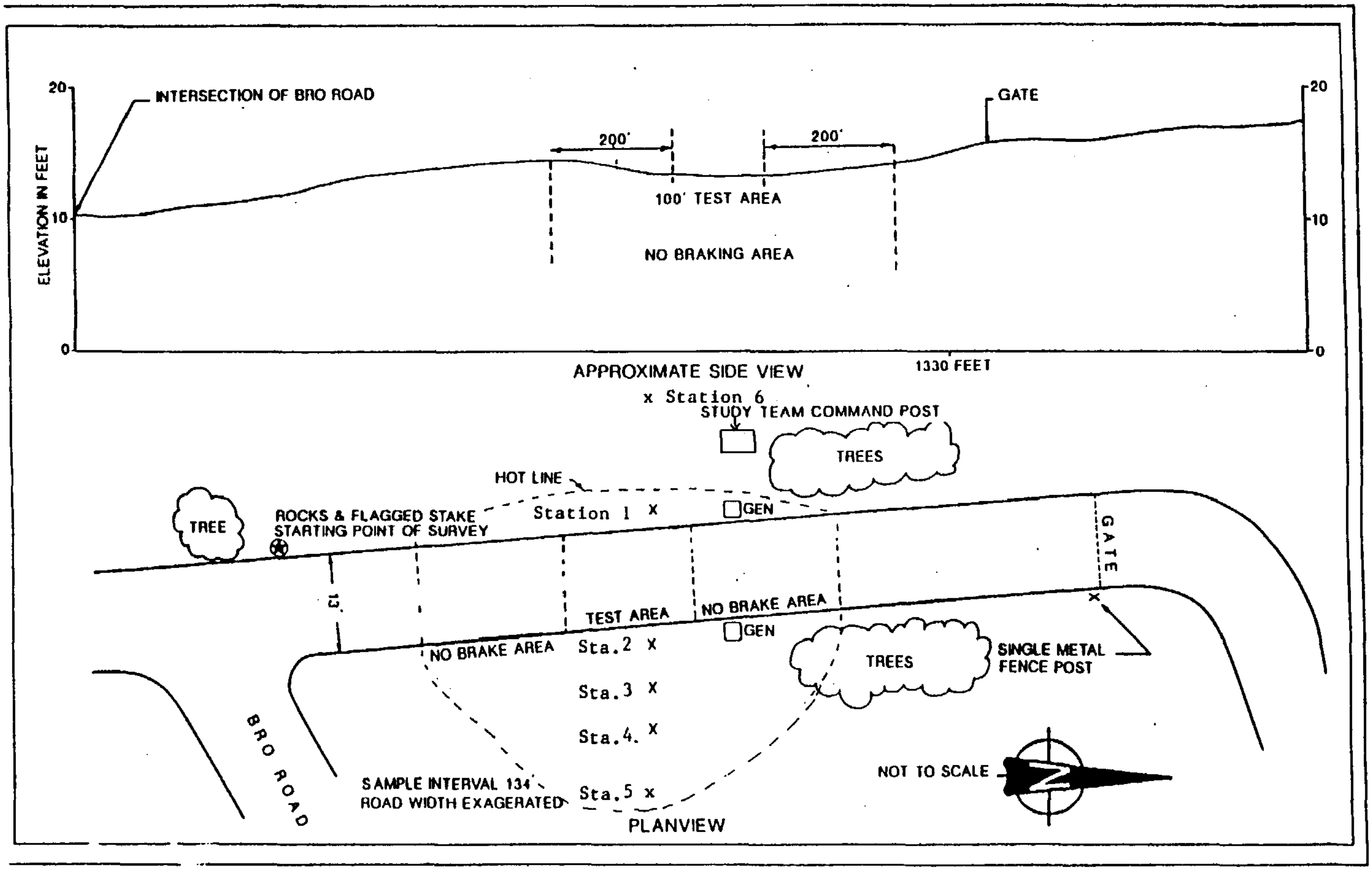
Three composite soil samples located in the pre-defined 100' test section were next obtained. Using a 12" x 12" template, an approximately 1/2" deep section of the road, at its 50' midpoint, was collected by using a sterile trowel. This sample was deposited into a clean collection bucket and the process repeated on the same 50' line at either side of the road. These three samples were gently homogenized, inserted to fill one 8 ounce sterile I-Chem jar, sealed, and labeled according to EPA protocol.

The same composite sampling technique was employed to gather samples at either end of the 100 foot test area for a total of 3 composite soil samples. Collectively, these samples would represent a cross section of both the asbestos fiber content and the silt content of the test section. (reference Sample Plan Figure VI-1, pg. 25)

A second type of soil sample was also obtained. At the end of each sampling day, dust from the rear bumper of the test vehicle was collected in a sterile I-Chem jar. These samples may help us to more thoroughly understand potential fiber re-entrainment.

---

* In order to confirm the presence of asbestos in this road, ten soil samples were previously collected and analyzed (via Polarized Light Microscopy (PLM) and Transmission Electron Microscopy (TEM)) during the Study's site selection phase (September, 1987). For an overview of the soil sampling methodology and sample results obtained, reference Sample Plan Appendix A - Selection of Study Sites.



MAP 2

ENVIRONMENTAL ASBESTOS STUDY
SITE-2 AREA OF INTEREST

C. Air Sampling

After the survey was completed and the soil samples were collected, the air sampling stations were laid out in a straight line, perpendicular to the road and at the midpoint of the test section (50'). Each sampling station (4 downwind and 2 upwind) consisted of several air pumps arranged adjacent to one another in order to perform different sampling functions. The upwind and downwind station locations were set with the pump configurations as described in the Sample Plan's Section V. and as seen in the Plan's Figures V-1 and VI-1 thru 2F.

1. Types and Rationale

8-hour samples

Those pumps which were dedicated to obtaining these full day samples were calibrated at 2.5 liters per minute. This amounts to a total volume of 1200 liters of air per 8 hour sampling day and is well above the 400 liters necessary to provide the minimum analytical detection level as established by EPA methods. This type of sample is designed to give an "overall" daily sample to use as a standard for total airborne constituents.

1- hour samples

Various 1-hour samples were taken to delineate specific conditions throughout the day.

Co-located samples

These side by side or duplicate samples were taken for both 1-hour and 8-hour samples to provide back-up data and to confirm the quality of the Study's data gathering procedures.

5 minute Grab samples

These samples were taken daily at the 10' Station by first exposing the sample filter while the test vehicle travelled the length of the test road and continuing to expose the filter for a total of 5 minutes. Although the minimum detection volume requirements are not met from the grab samples, their results may nontheless provide us information of peak concentrations from the passing of a vehicle.

2. Air Pump Locations

Station 1 - 25' upwind (bearing S85E)

Station 1 consisted of 2 Gillian high volume pumps calibrated to 13 liters per minute. This configuration enabled various types of testing to progress simultaneously (i.e., co-located and one hour samples for PCM and TEM analysis). On alternating days, when eight hour samples were required, two Gillian or Staplex pumps, calibrated to 2.5 liters per minute were placed here and when sample scheduling required, one hour (calibrated to 13 liters/minute) or eight hour (calibrated to 2.5 liters/minute) co-located samples were located at this station.

Station 2 - 10' downwind (bearing N85W)

Station 2 consisted of four Gillian or Staplex high volume pumps, arranged one adjacent to another and perpendicular to the road. Two of these pumps were calibrated to 13 liters per minute and those samples that came from these pumps were designated "Hi Vol" - one dedicated for PCM analysis and one dedicated for TEM analysis. Because we were unsure whether the Hi Vol sample filters would overload at this close downwind station and to better ensure the availability of data from this sampling distance we decided to include 2 additional pumps at this location which were calibrated to 7 liters per minute - one dedicated for PCM analysis and one dedicated for TEM analysis. As explained in Section V, a mid-Study analytical check on these samples allowed us to increase the 7 liter per minute pumps to Hi Vol for the last half of the six day study period.

Five minute grab samples were also taken during even-numbered hours at this station since the pumps used to collect the 7 liter per minute samples during odd-numbered hours were not in use.

Station 3 - 25' downwind (bearing N85W)

Station 3 consisted of two Gillian Hi-Vol pumps calibrated at 13 liters per minute so that one hour dedicated samples for TEM and PCM analysis could be accomodated.

Station 4 - 50' downwind (bearing N85W)

This was the most important station of all since the Copeland Model is based on a fifty foot distance from the line source. Since the model makes its predictions at this distance, each type of air sample and meteorological data were collected here: dedicated filters for both PCM and TEM analysis at one hour and eight hours intervals as well as co-located samples.

The automated meteorological staion was also positioned at Station 4. The station was leveled, oriented and elevated to the breathing zone.

Station 5 - 100' downwind (bearing N85W)

This station was initially expected to be placed 300' down wind in order to measure potentially distant fiber concentrations from the road. Topographic constraints (dense vegetation) dictated setting this station at the 100' mark. Two Gillian pumps calibrated at 2.5 liters per minute were located here to collect 8-hour samples for both TEM and PCM analysis on a daily basis.

Station 6 - 300' upwind (bearing N40W)

Not initially planned for in the Sample Plan and not initiated until the 4th day of the sampling period, this station was established to obtain Study area background values. 8-hour TEM and PCM samples were taken from a single 8-hour Gillian pump calibrated to 2.5 liters per minute.

III. METEOROLOGICAL AND TRAFFIC MONITORING

Meteorological Data

As detailed in the Sample Plan (Sections V.C and VI.H.3), a fully automated Young meteorological station with telemetry equipment, electronically obtained and transmitted data every 30 seconds to a Compaq Plus Personal Computer located in a van at the Study Team Command Post. The PC was equiped with a 20 megabyte hard disk 640 random access memory and a RS232 Serial Port.

For every 30 seconds of the 6 day study period, the meteorological data obtained and currently stored on a dBase III data file are:

Average Wind Speed
Average Wind Direction
Wind Direction Correction Factor
Average Temperature
Instantaneous Wind Speed
Instantaneous Wind Direction
Instantaneous Temperature
Weather staion volts
Validity check summary
Measurement Data
Measurement Date
Measurement Time
Corresponding Sample Number

Traffic Simulation

As detailed in the Sample Plan (Sections V.D) a compact size and weight Test Car was utilized to maintain a 1 vehicle pass per 15 minute interval on the test road. The test car driver accelerated to 30 mph by the time he/she reached the test section of the road, maintained 30 mph over the test section and began to decelerate and brake once past the "no braking" section. While passing the command post, the driver honked the horn to alert the computer operator to indicate the exact time the car was passing. At this moment, a printout of the met data was obtained and the time of the vehicle pass was manually entered onto this printout. In this way we were assured of having an exact reading of the actual meteorological conditions at the precise moment that the test vehicle made a pass and as a backup to possible computer failure.

A reporting log was kept within the test car and filled in by the test car driver. The log required the following information:

Name of Test Driver
Time of Vehicle Pass
Speed of Vehicle
Time of Non-Test Car Vehicle Pass
Type of Non-Test Car Vehicle

The Test Car driver was required to be dressed in Level C (reference Sample Plan Appendix H).

IV. PHOTOGRAPHS

This section will give the reader an idea of the test site and environs as well as the equipment utilized in the Study. Reference the Sample Plan for additional photographs.

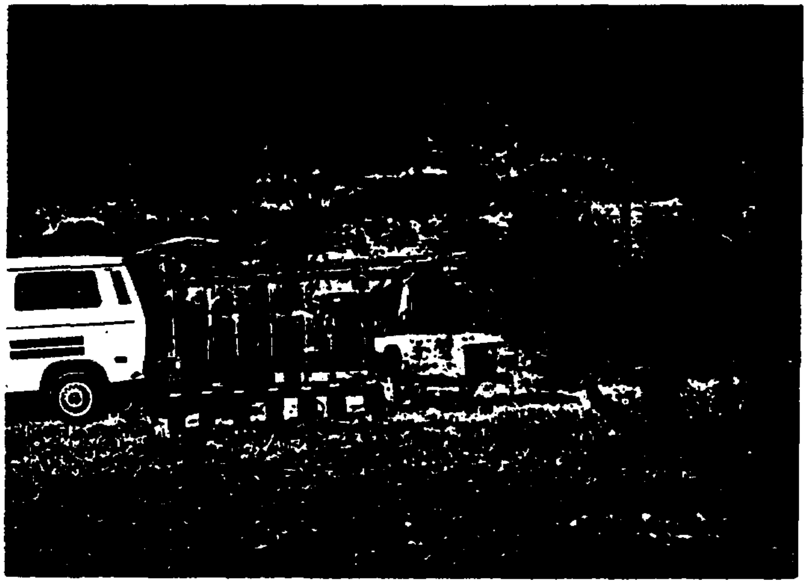
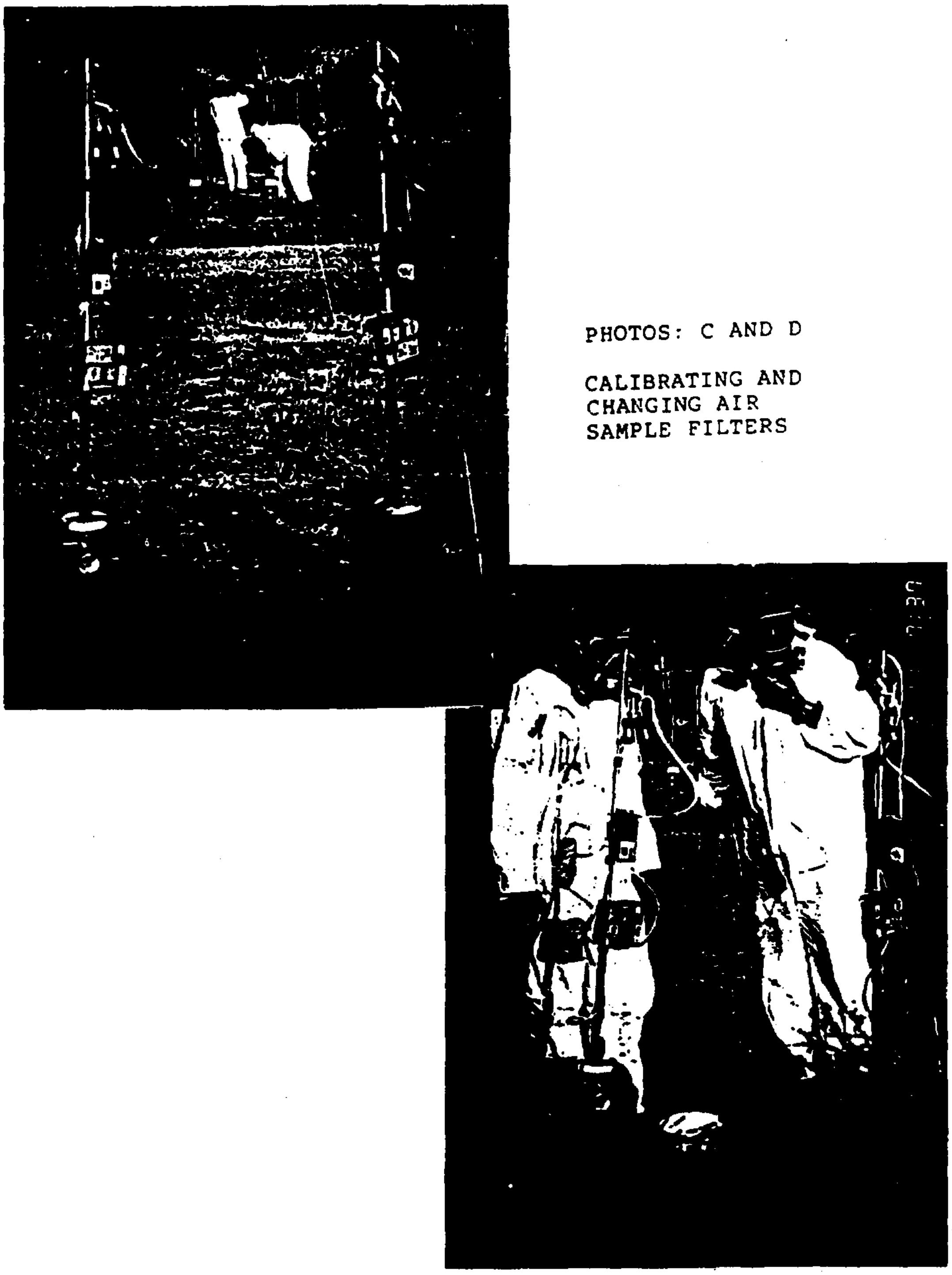


PHOTO A: UPWIND AT THE COMMAND POST, AIR SAMPLING PUMPS BEING ASSEMBLED

PHOTO B: AIR SAMPLING PUMPS ARRANGED IN THE FIELD, LOOKING DOWNWIND ACROSS THE TEST ROAD



PHOTOS: C AND D

CALIBRATING AND
CHANGING AIR
SAMPLE FILTERS

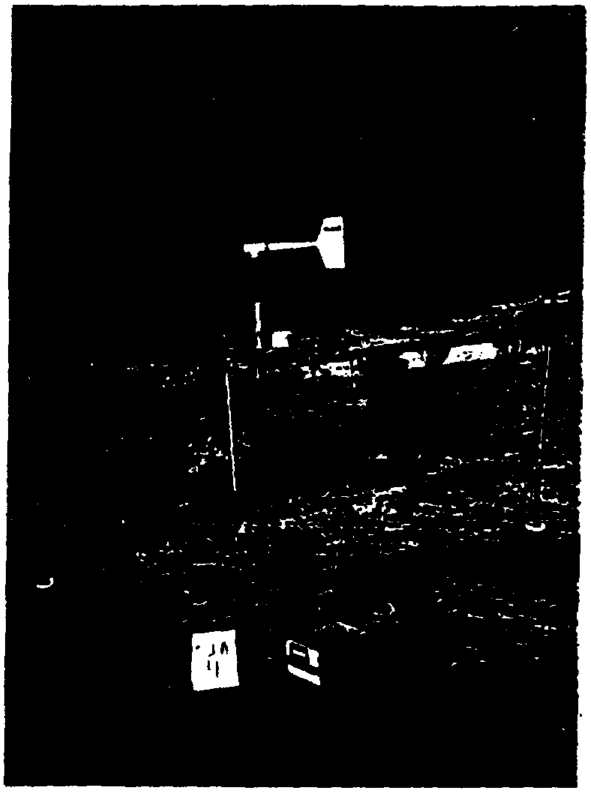


PHOTO E: STATION 4 AND THE METEOROLOGICAL STATION

PHOTO F: MEASURING THE HUMIDITY HOURLY

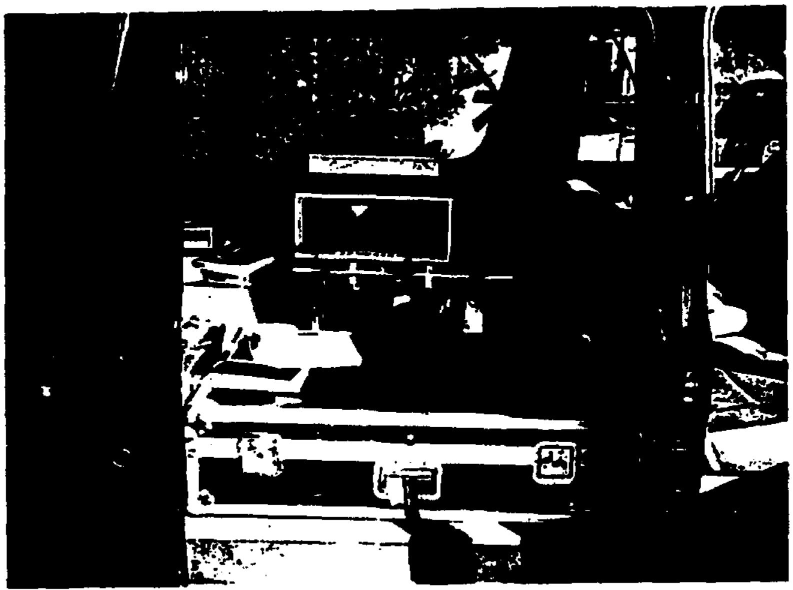


PHOTO G: THE METEOROLOGICAL STATION AT STATION 4 IS HOOKED UP TO THIS COMPUTER IN A VAN AT THE STUDY TEAM COMMAND POST

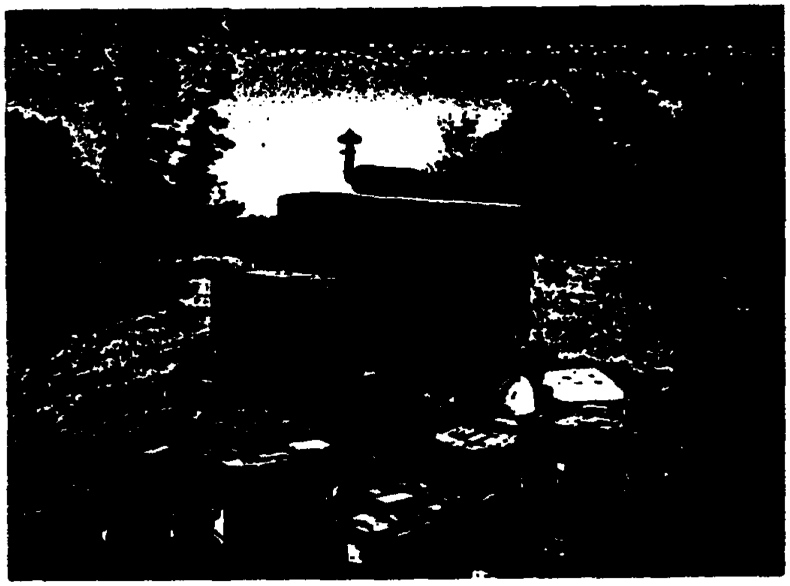


PHOTO H: ONE OF TWO 15K ELECTRICAL GENERATORS WHICH POWERED THE AIR SAMPLING PUMPS, THE METEOROLOGICAL STATION AND THE COMPUTER.

PHOTO K: CONTAMINATED AND DISPOSABLE CLOTHING, USED RESPIRATOR CARTRIDGES AND OTHER SAMPLING EQUIPMENT ARE STORED IN APPROPRIATELY LABELED PLASTIC BAGS UNTIL REMOVED BY A LICENSED ASBESTOS CONTRACTOR

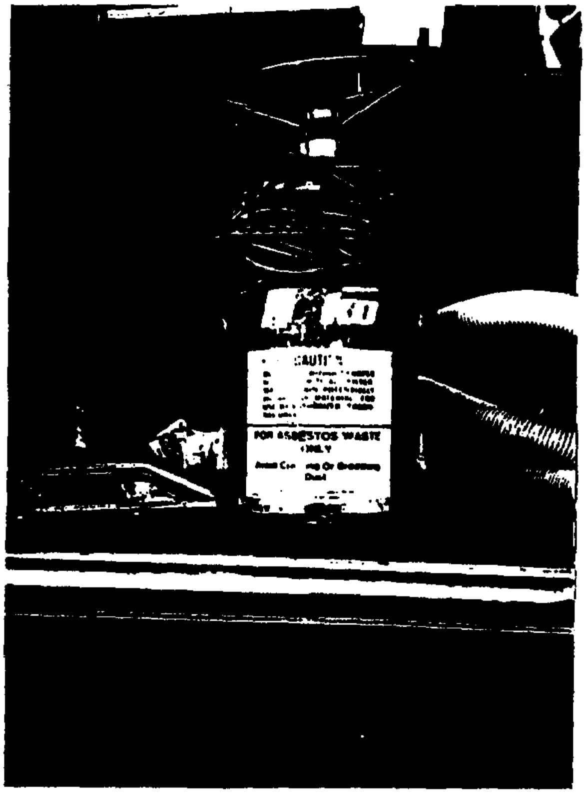


PHOTO L: A HIGH EFFICIENCY PARTICULATE (HEPA) VACUUM WAS SECURED TO THOROUGHLY VACUUM ALL THE VEHICLES USED ON THE STUDY SITE

PHOTO I: THE TEST VEHICLE TRAVELING AT 30 MILES PER HOUR; STATION 2 (10') IS SEEN IN THE FOREGROUND

PHOTO J: THE DUST GENERATED BY THE PASSING VEHICLE WITHIN MOMENTS AFTER IT HAS TRAVELED BEYOND THE TEST SECTION.

V. LABORATORY SERVICES AND ANALYSIS

Mid-Study Sample Analysis

Mid-way through the six day study and after the third day of sampling, we carefully selected samples which were taken when the wind speed and direction most ideally met study criteria and rushed them to two different laboratories for overnight PCM and TEM analysis. The results helped us to determine whether we were appropriately loading the filters so that we would be able to correct the flow rates, distances or number of vehicle passes for the remaining three sampling days. If the filters were found to be appropriately loaded, we also wanted to know if measurable asbestos fibers were found on them. If no fibers were to be found under the best of sampling conditions, the Study Team would have packed up and departed for home.

The mid-study laboratory results, however, indicated that even the Hi-Vol samplers at 13 liters per minute were appropriately loaded and that fibers had been found on all submitted samples. We corrected our study at that point by discontinuing the pumps at Station 2 (which were drawing 7 liters per minute) since the Hi-Vols were adequate.

Laboratory Selection and Services

Finding a laboratory with the desired capabilities, expertise and equipment to handle the Study's approximately 150 PCM samples, 150 TEM samples and several soil samples for both PCM and TEM analysis was given priority attention. Several reputable laboratories were screened for their capabilities, methods, internal QA/QC measures, time frames and costs. After careful consideration by Region 9 and the Environmental Response Team (ERT), final laboratory selection was made by ERTs REAC contractor.

All samples were carefully cushioned and packaged in order to avoid shifting and dislodging of the fibers from the cassette filter material, and upon selection of the laboratory to perform the analytical services, the samples were hand carried to their destination.

Upon completion of the laboratory analysis, the laboratory report and all raw data were submitted to another laboratory which had been selected to perform rigorous validation and quality assurance review.

For a discussion of the analytical methods utilized, reference the Sample Plan and its appendices.

VI. INITIAL DATA MANIPULATIONS AND DISPLAY

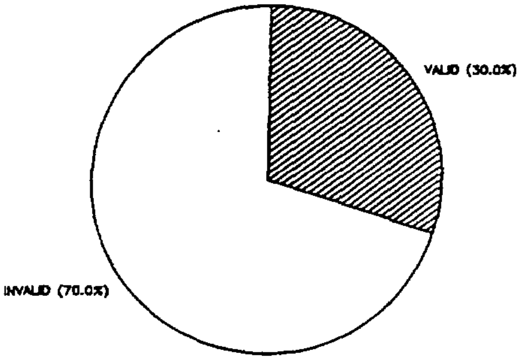
The Quality Assurance Management Section of EPA Region 9 has reviewed all data associated with this Study and has concluded that the final data is valid for all purposes. The data review report is available to interested parties.

The provided selection of graphs and charts were determined to be of the most likely initial interest to the wide spectrum of anticipated readers. They are not intended to be comprehensive nor analytical in scope. They are offered to provide a quick summary, simply displayed and understandable. Because all meteorological and sampling data have now been computerized on dBase III, they may be statistically manipulated and displayed in a wide variety of reports not included in this section, yet easily retrievable. We hope that they stimulate follow-up interest and we encourage your requests for additional data reports or statistical analysis.

METEOROLOGICAL DATA

Valid = % of the sampling time per day that the wind direction and speed simultaneously met the study criteria.

10/13/87



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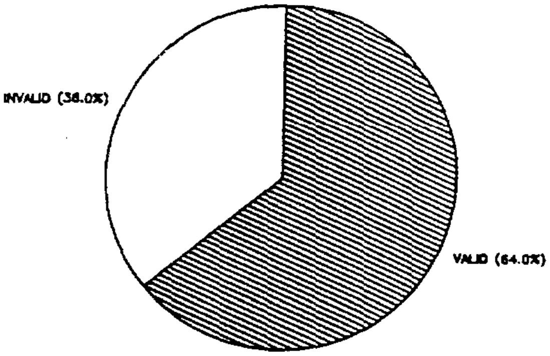

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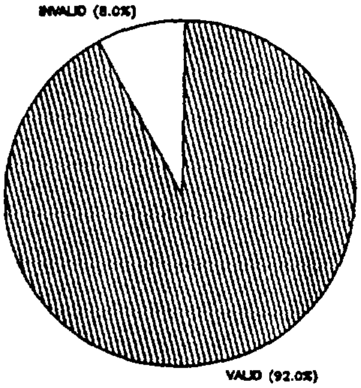

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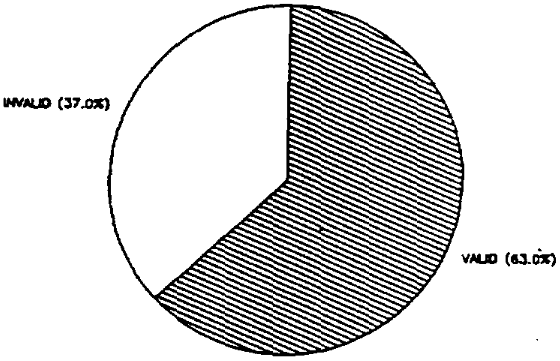

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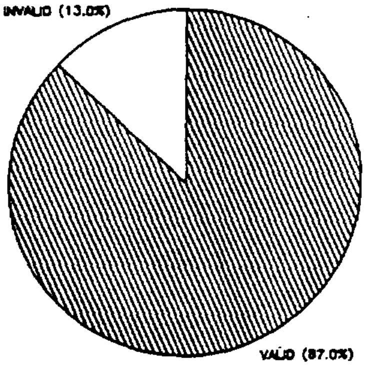
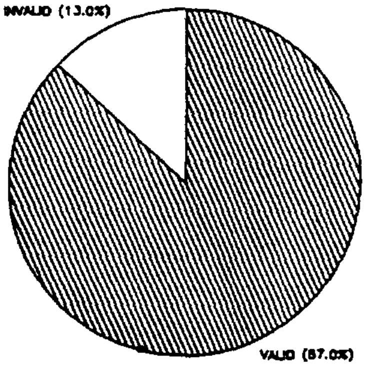
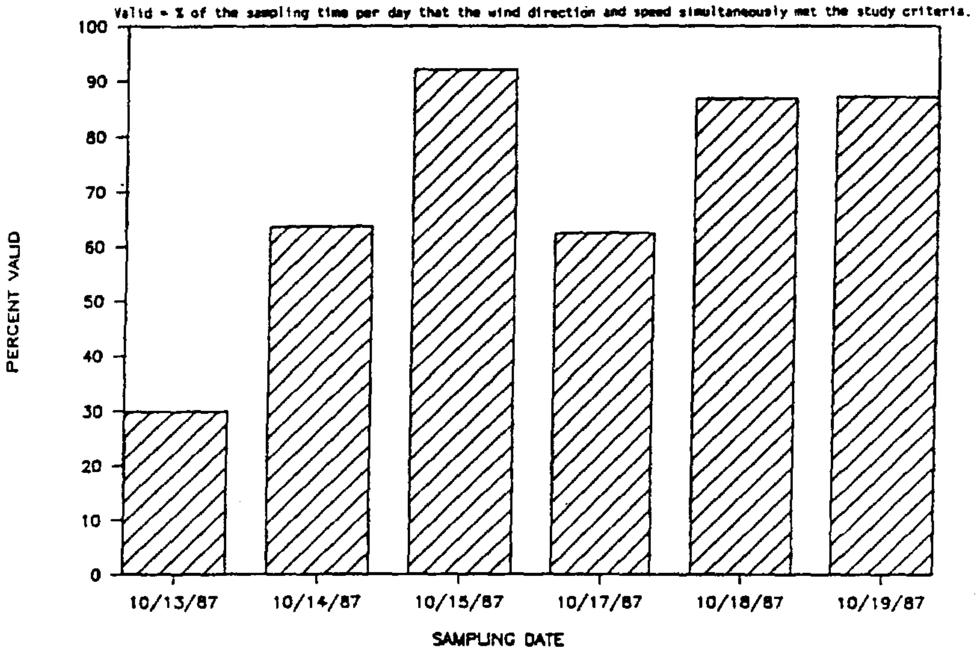


10/19/87

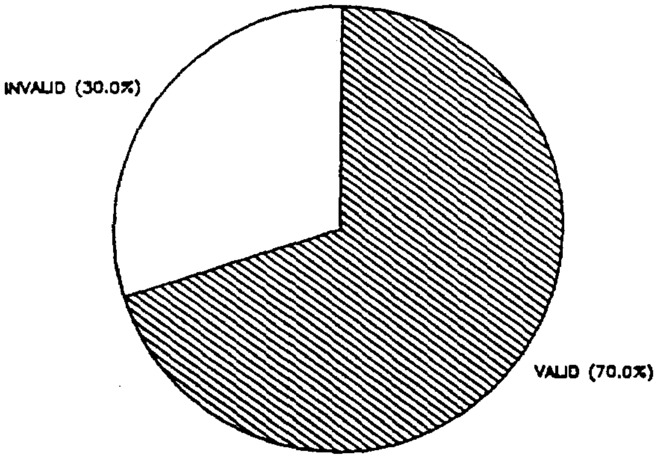


VALID WIND MEASUREMENTS



Note: Study criteria requires that the wind direction be within 45° perpendicular to the road (between 233° - 323°) with a minimum wind speed of 1.1 miles per hour.

METEOROLOGICAL DATA - OVERALL AVERAGE



Environmental Asbestos Study Soil Sample Data

These samples were taken from the road test area and represent the Range and Median of asbestos structure concentrations as determined by Polarized Light Microscopy (PLM) and Transmission Electron Microscopy (TEM) analysis.

	PLM % Asbestos by Mass		TEM % Asbestos by Mass	
RANGE	Minimum	1	Minimum	0
	Maximum	4	Maximum	7.8
MEDIAN		2		1.8

Total # Samples Analyzed by PLM: 14

Total # Samples Analyzed by TEM: 7

Environmental Asbestos Study Air Sample Data: Range and Median of 1 HOUR samples, by Station, determined by PCM and TEM analysis, over the six (6) day Study.

		PHASE CONTRAST MICROSCOPY and Dispersion Staining	TRANSMISSION ELECTRON MICROSCOPY			
UPWIND STATION	#Samples Analyzed	# Total Structures/cc	# Total Asbestos Structures/cc	# Total Asbestos Structures/cc (PCM equivalent by size)*	# Total Asbestos Structures/cc (PCM equivalent by mass conv.)**	Total Asbestos Mass Concentration ng/cc
Station		Med. 0.010	Med. 0.032	Med. 0.019	Med. 1.287	Med. 38.6
1	31	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.0
25'		Max. 0.090	Max. 0.451	Max. 0.034	Max. 48.483	Max. 1454.5
DOWNWIND STATIONS						
Station		Med. 0.210	Med. 1.188	Med. 0.092	Med. 37.590	Med. 1127.7
2	43	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.0
10'		Max. 0.900	Max. 8.996	Max. 1.323	Max. 7899.180	Max. 236975.4
Station		Med. 0.130	Med. 1.089	Med. 0.085	Med. 81.618	Med. 2448.5
3	23	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.0
25'		Max. 0.260	Max. 4.306	Max. 0.421	Max. 535.610	Max. 16068.3
Station		Med. 0.080	Med. 0.831	Med. 0.038	Med. 28.510	Med. 855.3
4	31	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.0
50'		Max. 0.230	Max. 1.745	Max. 0.138	Max. 285.263	Max. 8557.9
Station		Med. 0.000	Med. 0.000	Med. 0.000	Med. 0.000	Med. 0.0
5	0	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.0
100'		Max. 0.000	Max. 0.000	Max. 0.000	Max. 0.000	Max. 0.0

* Only asbestos structures >5 microns in length and >.25 microns in diameter with a 3:1 aspect ratio are counted.

** The conversion factor applied: 30 ug/m3 = 1 fiber/ml

Environmental Asbestos Study Air Sample Data: Range and Median of 8 HOUR samples, by Station, determined by PCM and TEM analysis, over the six (6) day Study.

		PHASE CONTRAST MICROSCOPY and Dispersion Staining	TRANSMISSION ELECTRON MICROSCOPY			
UPWIND STATIONS	#Samples Analyzed	# Total Structures/cc	# Total Asbestos Structures/cc	# Total Asbestos Structures/cc (PCM equivalent by size)*	# Total Asbestos Structures/cc (PCM equivalent by mass conv.)**	Total Asbestos Mass Concentration ng/cc
Station 1 25'	9	Med. 0.010	Med. 0.114	Med. 0.017	Med. 6.167	Med. 185.0
		Min. 0.000	Min. 0.016	Min. 0.012	Min. 0.120	Min. 3.6
		Max. 0.160	Max. 1.000	Max. 0.041	Max. 37.203	Max. 1116.1
Station 6 200'	Backgrnd 1	0.005	0.013	0.013	0.017	0.5
DOWNWIND STATIONS						
Station 2 10'	0	Med. 0.000	Med. 0.000	Med. 0.000	Med. 0.000	Med. 0.0
		Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.0
		Max. 0.000	Max. 0.000	Max. 0.000	Max. 0.000	Max. 0.0
Station 3 25'	0	Med. 0.000	Med. 0.000	Med. 0.000	Med. 0.000	Med. 0.0
		Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.0
		Max. 0.000	Max. 0.000	Max. 0.000	Max. 0.000	Max. 0.0
Station 4 50'	10	Med. 0.090	Med. 0.374	Med. 0.023	Med. 12.988	Med. 389.6
		Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.000	Min. 0.0
		Max. 0.140	Max. 1.068	Max. 0.134	Max. 179.107	Max. 5373.2
Station 5 100'	6	Med. 0.035	Med. 0.344	Med. 0.024	Med. 10.053	Med. 301.6
		Min. 0.000	Min. 0.183	Min. 0.018	Min. 5.400	Min. 162.0
		Max. 0.110	Max. 0.811	Max. 0.031	Max. 17.860	Max. 535.8

* Only asbestos structures >5 microns in length and >.25 microns in diameter with a 3:1 aspect ratio are counted.

** The conversion factor applied: 30 ug/m3 = 1 fiber/ml

Air Resources Board
Cothrin Ranch Road Study

State of California

M E M O R A N D U M

To : Don Ames, Chief
Toxic Air Contaminant Control Branch

Date : February 21, 1989

Subject: Results of Laboratory Analysis for Asbestos on Samples Taken During Serpentine Covered Road Study

Thru : George Lew
Peter Ouchida KJ

James E. McCormack MAC
Monitoring and Laboratory Division
From : Air Resources Board

In support of Stationary Source Division's Technical Analysis Section, an unpaved road study was performed on August 27, 1988, to determine asbestos emissions from a serpentine covered road. The study involved sampling upwind and downwind of a section of unpaved road covered with serpentine aggregates while two vehicles drove continuously back and forth at a specific speed.

Sampling was performed in the Sunridge Ranch Subdivision. Sunridge Ranch is located in El Dorado County on Latrobe Road, mid way between Highway 50 and the town of Latrobe. Figure 1 is a map of the Sunridge Ranch and shows the section of road used in this study.

Four Serra-Anderson Model 241 dicbotomus samplers were set up to collect dust on polycarbonate filters for asbestos analysis. One sampler was located 10 feet upwind of the road and the remaining three were located at 25, 50, and 100 feet downwind of the road. A layout drawing of the test section of road and the location of the samplers, and meteorological station relative to the road is shown in Figure 2. Figure 3 shows a schematic of a dichotomus sampler. The dichotomus samplers have two filters: a course cut filter (course) and a fine cut filter (fine). The sampler is designed such that the course filter collects all particulate matter in the sample air stream with an areodynamic diameter between 10 and 3 microns and the fine filter collects all particulate matter in the sampled air stream with an aerodynamic diameter less than 3 microns.

The analysis was performed by an ARB contract laboratory, RJ Lee, located in Berkeley, California. The analytical method for asbestos is based on EPA's AHERA Analytical Procedure. A copy of the procedure is presented in Appendix I. All fibers and bundles of fibers are classified as structures. Each structure is assigned a length and a diameter based on EPA's AHERA Analytical Procedure.

RJ Lee's report on the samples is contained in Appendix II and consists of three tables. Table I (RJ Lee's report) gives the total asbestos structure concentration. Table II (RJ Lee's Report) gives the range of possible concentrations based on a 95% confidence limits for all asbestos structures. 95% confidence intervals are calculated based on a Poisson distribution. Table III (RJ Lee's Report) gives the asbestos structures concentration for structures greater than 5 microns.

The Sunridge Ranch Sampling Parameters are presented in Table I. In test "E" the vehicle speed was 10 mph. The remaining two tests ("F" and "G") were performed at a vehicle speed of 20 mph. The wind speed averaged 5.5 mph and always in the desired direction that placed the samplers in their proper upwind-downwind orientation.

The results of the analytical analysis is presented in Table II. Filters "F-4C-48" AND "G-1C-50" were damaged and not analyzed. The concentration downwind of the road ranged between 4 95 structures per cubic centimeters. The upwind asbestos concentration was always less than three structures per cubic centimeters. No consistent difference in concentration was noted between the sampler at 25 feet and the sampler at 50 feet.

cc: Susan Huscroft
Gary Agid

Figure 1

Plat Map of Sunridge Ranch Subdivision

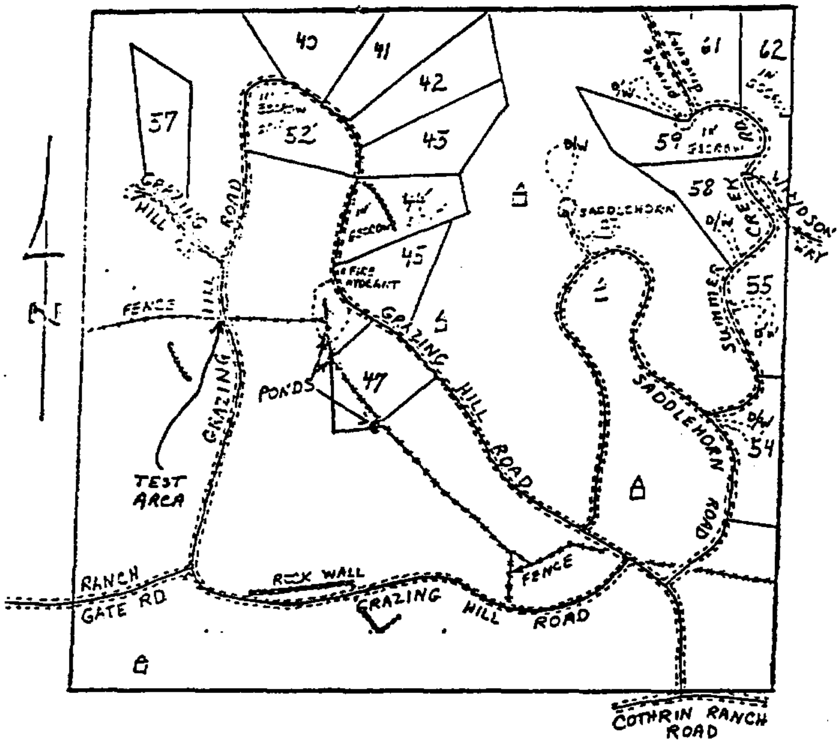


Figure 2

Unpaved Road Test Area

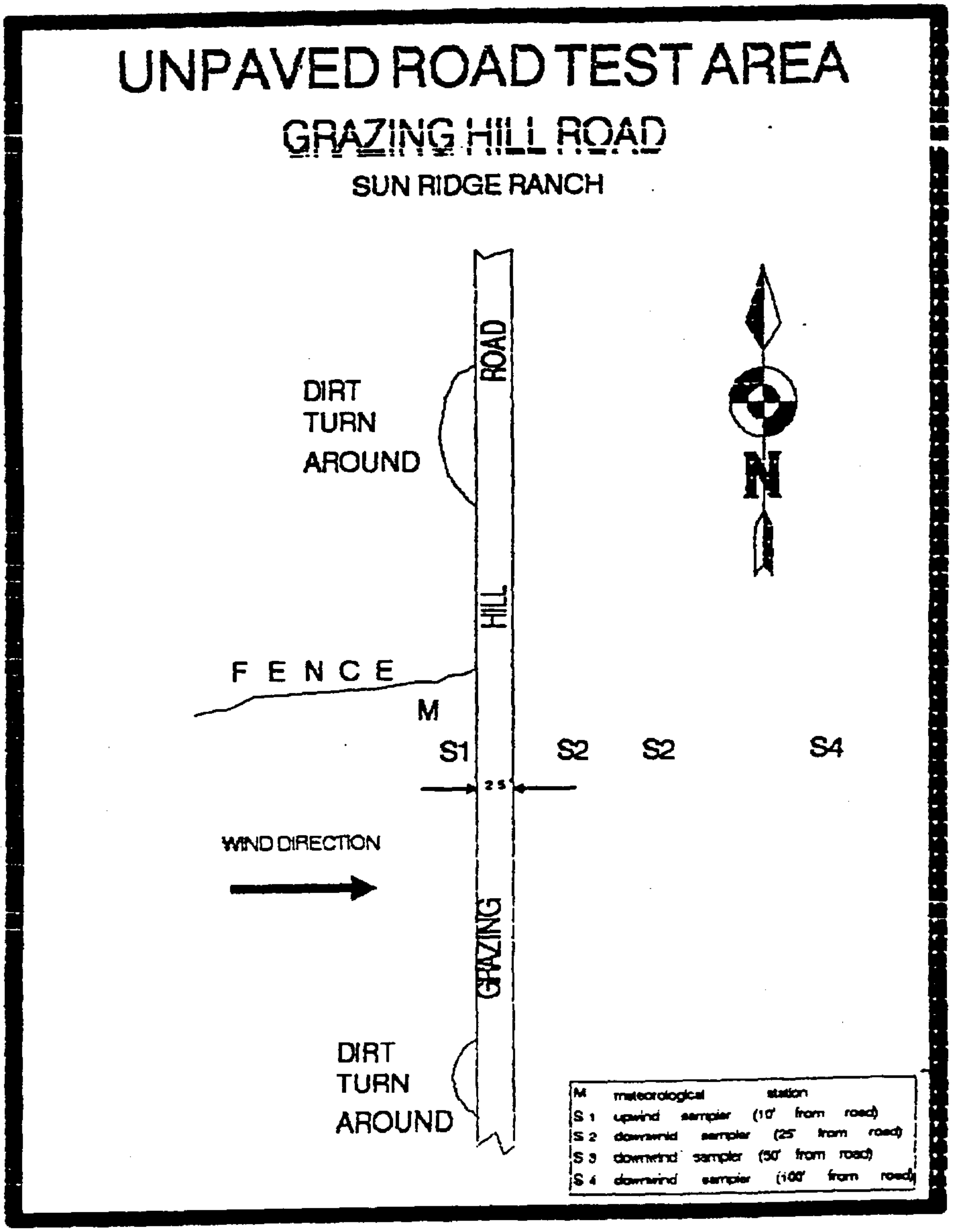


Table 3

Serra-Anderson Dichotomus Sampler

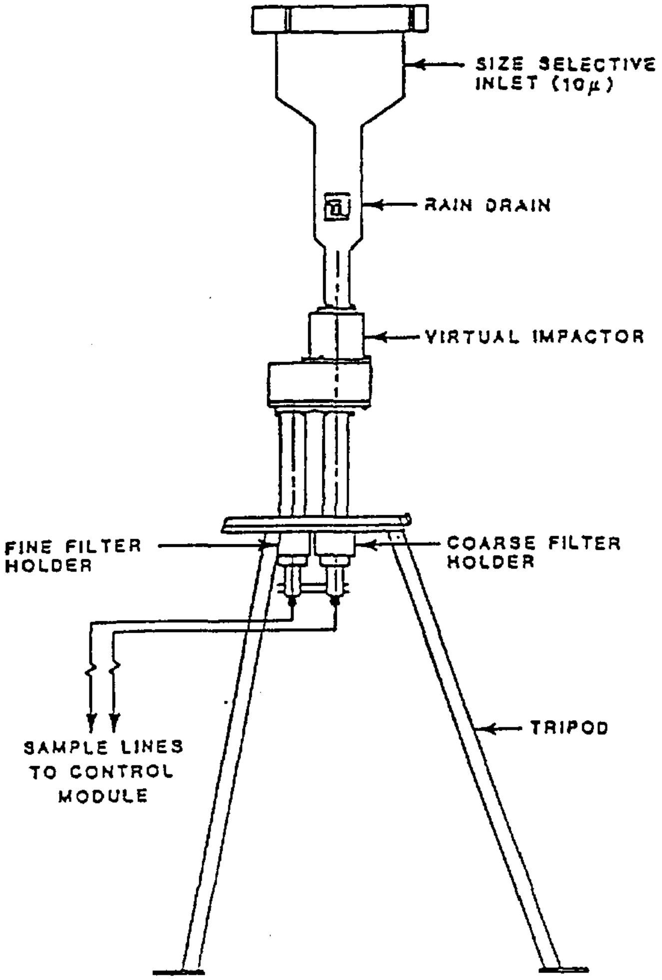


Table I

Sunridge Ranch Sampling Parameters

test number	************ Sampling ************ date	start	end	duration	vehicle speed	vehicle miles traveled		wind speed
						car A	car B	
E	08/27/87	1330	1434	60	10	9.0	9.0*	6
F	08/27/87	1530	1630	60	20	14.4	14.8	5.5
G	08/27/87	1650	1750	60	20	14.4	14.1	5

Notes:

Very little dust at 10 mph.
Dust more than doubled at 20 mph over 10 mph.
One round trip, from turnaround and back to same turnaround, was 600 feet.
* Estimate

TABLE II

SAMPLING PARAMETERS

sample	STRUCTURE COUNTS		CONCENTRATION STRUCTURES/CC	
number	ALL@	< 5um+	ALL@	< 5um+
E-1F-33	36	0	0.3375	<0.0094
E-1C-34	12	0	1.0106	<0.0842
E-2F-35	42	2	0.7876	0.0375
E-2C-36	32	1	13.474	0.4211
E-3F-37	31	1	0.4844	0.0156
E-3C-38	33	0	13.895	<0.4211
E-4F-39	24	1	0.2250	0.0094
E-4C-40	25	8	4.2106	1.3474
F-1F-41	37	1	3.3755	0.0912
F-1C-42	26	0	0.5282	<0.0203
F-2F-43	30	1	27.369	0.9123
F-2C-44	33	0	0.6704	<0.0203
F-3F-45	23	1	20.983	0.9123
F-3C-46	31	4	3.1487	0.4063
F-4F-47	40	2	18.246	0.9123
F-4C-48*	N/A	N/A	N/A	N/A
G-1F-49	31	0	0.3149	<0.0102
G-1C-50*	N/A	N/A	N/A	N/A
G-2F-51	31	11	3.1487	1.1173
G-2C-52	47	2	21.439	0.9123
G-3F-53	29	2	2.9455	0.2031
G-3C-54	30	0	27.369	<0.9123
G-4F-55	30	3	1.5235	0.1524
G-4C-56	103	4	93.967	3.6492

Note

E-1F-33 E---> Test number
1---> sampler number
F---> filter (fine)
33---> sequence number

* Filters were damaged and not analyzed.
@ Includes all structures independent of length.
\+ Includes only those structures with a measured length greater than 5 microns.

APPENDIX II

RJ Lee Report

RJ LeeGroup
The Materials Characterization Specialists

October 24, 1988

Mr. James E. McCormack
CARB
P.O. Box 2815
Sacramento, Ca 95812

RE: TEM Asbestos Results for Samples as Shown on Tables I thru III
RJL Job No. AAC807956

Dear Mr. McCormack:

Enclosed are the revised results from the scanning transmission electron microscopy (STEM) asbestos analysis of the above referenced samples using proposed EPA Level II analysis.

Table I lists each sample identification number, area analyzed, sample volume, structure counts, analytical sensitivity, and the concentration of asbestos. Table II lists the 95% confidence limits for the analyses, based on the Poisson distribution. Table III lists the asbestos structure concentrations for structures greater than or equal to 5 microns.

These results are submitted pursuant to RJ Lee Group's current terms and conditions of sale, including the company's standard warranty and limitation of liability provisions and no responsibility or liability is assumed for the manner in which the results are used or interpreted.

If you have any questions, feel free to call me.

Very truly yours,

Kyle Bishop

Kyle Bishop
Division Manager

KMB

Enclosures

Table I

Total Asbestos Structure Concentration
Project AAC807956

Sample #	Client Sample #	Analyzed Area (sq mm)	Sample Volume (liters)	Structure Counts Chrysotile	Structure Counts Amphibole	Analytical Sensitivity (s/sq mm)	Analytical Sensitivity (s/cc)	Concentration (s/sq mm)	Concentration (s/cc)
CT1716	E-1F-33	0.0722	975.0	36	0	13.9	0.0094	498.6	0.3375
CT1717	E-1C-34	0.0722	108.6	12	0	13.9	0.0842	166.2	1.0106
CT1718	E-2F-35	0.0361	975.0	42	0	27.7	0.0188	1163.4	0.7876
CT1719	E-2C-36	0.0144	108.6	32	0	69.3	0.4211	2216.1	1.3474*10^1
CT1720	E-3F-37	0.0433	975.0	31	0	23.1	0.0156	715.6	0.4844
CT1721	E-3C-38	0.0144	108.6	33	0	69.3	0.4211	2285.3	1.3895*10^1
CT1722	E-4F-39	0.0722	975.0	24	0	13.9	0.0094	332.4	0.2250
CT1723	E-4C-40	0.0361	108.6	25	0	27.7	0.1684	692.5	4.2106
CT1724	F-1C-41	0.0722	100.2	37	0	13.9	0.0912	512.5	3.3755
CT1725	F-1F-42	0.0361	900.0	26	0	27.7	0.0203	720.2	0.5282
CT1726	F-2C-43	0.0072	100.2	30	0	138.5	0.9123	4155.1	2.7369*10^1
CT1727	F-2F-44	0.0361	900.0	33	0	27.7	0.0203	914.1	0.6704
CT1728	F-3C-45	0.0072	100.2	23	0	138.5	0.9123	3185.6	2.0983*10^1
CT1729	F-3F-46	0.0072	900.0	31	0	138.5	0.1016	4293.6	3.1487
CT1730	F-4C-47	0.0144	100.2	40	0	69.3	0.4562	2770.1	1.8246*10^1
CT1731	F-4F-48	N/A	Blank	N/A	N/A	N/A	N/A	N/A	N/A
CT1732	G-1F-49	0.0722	900.0	31	0	13.9	0.0102	429.4	0.3149
CT1733	G-1C-50	N/A	Blank	N/A	N/A	N/A	N/A	N/A	N/A
CT1734	G-2F-51	0.0072	900.0	31	0	138.5	0.1016	4293.6	3.1487
CT1735	G-2C-52	0.0144	100.2	47	0	69.3	0.4562	3254.8	2.1439*10^1
CT1736	G-3F-53	0.0072	900.0	29	0	138.5	0.1016	4016.6	2.9455
CT1737	G-3C-54	0.0072	100.2	30	0	138.5	0.9123	4155.1	2.7369*10^1
CT1738	G-4F-55	0.0144	900.0	30	0	69.3	0.0508	2077.6	1.5235
CT1739	G-4C-56	0.0072	100.2	103	0	138.5	0.9123	1.4*10^4	9.3967*10^1

N/A Not Analyzed

Authorized Signature

Date Tuesday, October 25, 1988

RJ Lee Group, Inc.
Berkeley

2424 6th Street
Berkele Ca 94710

(415) 486-8319
Telefax (415) 486-0927

Table II

95% Confidence Limits (Poisson) For All Asbestos Structures

Project AAC807956

Sample #	Client Sample #	Concentration (s/sq mm)	Concentration (s/cc)	Estimated Ranges of Concentrations (s/sq mm)	Estimated Ranges of Concentrations (s/cc)
CT1716	E-1F-33	498.6	0.3375	346.3 - 692.5	0.2344 - 0.4688
CT1717	E-1C-34	166.2	1.0106	83.1 - 290.9	0.5053 - 1.7685
CT1718	E-2F-35	1163.4	0.7876	831.0 - 1578.9	0.5625 - 1.0688
CT1719	E-2C-36	2216.1	1.3474*10^1	1523.5 - 3116.3	9.2634 - 1.8948*10^1
CT1720	E-3F-37	715.6	0.4844	484.8 - 1015.7	0.3281 - 0.6875
CT1721	E-3C-38	2285.3	1.3895*10^1	1592.8 - 3185.6	9.6844 - 1.9369*10^1
CT1722	E-4F-39	332.4	0.2250	207.8 - 498.6	0.1406 - 0.3375
CT1723	E-4C-40	692.5	4.2106	443.2 - 1024.9	2.6948 - 6.2317
CT1724	F-1C-41	512.5	3.3755	360.1 - 706.4	2.3720 - 4.6527
CT1725	F-1F-42	720.2	0.5282	470.9 - 1052.6	0.3453 - 0.7719
CT1726	F-2C-43	4155.1	2.7369*10^1	2770.1 - 5955.7	1.8246*10^1 - 3.9229*10^1
CT1727	F-2F-44	914.1	0.6704	637.1 - 1274.2	0.4672 - 0.9344
CT1728	F-3C-45	3185.6	2.0983*10^1	2077.6 - 4709.1	1.3685*10^1 - 3.1018*10^1
CT1729	F-3F-46	4293.6	3.1487	2908.6 - 6094.2	2.1330 - 4.4691
CT1730	F-4C-47	2770.1	1.8246*10^1	2008.3 - 3739.6	1.3228*10^1 - 2.4632*10^1
CT1731	† F-4F-48	N/A	N/A	N/A - N/A	N/A - N/A
CT1732	G-1F-49	429.4	0.3149	290.9 - 609.4	0.2133 - 0.4469
CT1733	† G-1C-50	N/A	N/A	N/A - N/A	N/A - N/A
CT1734	G-2F-51	4293.6	3.1487	2908.6 - 6094.2	2.1330 - 4.4691
CT1735	G-2C-52	3254.8	2.1439*10^1	2354.6 - 4293.6	1.5509*10^1 - 2.8281*10^1
CT1736	G-3F-53	4016.6	2.9455	2631.6 - 5817.2	1.9298 - 4.2659
CT1737	G-3C-54	4155.1	2.7369*10^1	2770.1 - 5955.7	1.8246*10^1 - 3.9229*10^1
CT1738	G-4F-55	2077.6	1.5235	1385.0 - 2977.8	1.0157 - 2.1837
CT1739	G-4C-56	1.4*10^4	9.3967*10^1	1.1*10^4 - 1.7*10^4	7.5449*10^1 - 1.1248*10^2

† Blank
N/A Not Analyzed

Table III

Asbestos Structure Concentration For Structures ≥ 5 µm
Project AAC807956

Sample #	Client Sample #	Analyzed Area (sq mm)	Sample Volume (liters)	Structure Counts		Analytical Sensitivity		Concentration	
				Chrysotile	Amphibole	(s/sq mm)	(s/cc)	(s/sq mm)	(s/cc)
CT1716	E-1F-33	0.0722	975.0	0	0	13.9	0.0094	<13.9*	<0.0094*
CT1717	E-1C-34	0.0722	108.6	0	0	13.9	0.0842	<13.9*	<0.0842*
CT1718	E-2F-35	0.0361	975.0	2	0	27.7	0.0188	55.4	0.0375
CT1719	E-2C-36	0.0144	108.6	1	0	69.3	0.4211	69.3	0.4211
CT1720	E-3F-37	0.0433	975.0	1	0	23.1	0.0156	23.1	0.0156
CT1721	E-3C-38	0.0144	108.6	0	0	69.3	0.4211	<69.3*	<0.4211*
CT1722	E-4F-39	0.0722	975.0	1	0	13.9	0.0094	13.9	0.0094
CT1723	E-4C-40	0.0361	108.6	8	0	27.7	0.1684	221.6	1.3474
CT1724	F-1C-41	0.0722	100.2	1	0	13.9	0.0912	13.9	0.0912
CT1725	F-1F-42	0.0361	900.0	0	0	27.7	0.0203	<27.7*	<0.0203*
CT1726	F-2C-43	0.0072	100.2	1	0	138.5	0.9123	138.5	0.9123
CT1727	F-2F-44	0.0361	900.0	0	0	27.7	0.0203	<27.7*	<0.0203*
CT1728	F-3C-45	0.0072	100.2	1	0	138.5	0.9123	138.5	0.9123
CT1729	F-3F-46	0.0072	900.0	4	0	138.5	0.1016	554.0	0.4063
CT1730	F-4C-47	0.0144	100.2	2	0	69.3	0.4562	138.5	0.9123
CT1731	F-4F-48	N/A	Blank	N/A	N/A	N/A	N/A	N/A	N/A
CT1732	G-1F-49	0.0722	900.0	0	0	13.9	0.0102	<13.9*	<0.0102*
CT1733	G-1C-50	N/A	Blank	N/A	N/A	N/A	N/A	N/A	N/A
CT1734	G-2F-51	0.0072	900.0	11	0	138.5	0.1016	1523.5	1.1173
CT1735	G-2C-52	0.0144	100.2	2	0	69.3	0.4562	138.5	0.9123
CT1736	G-3F-53	0.0072	900.0	2	0	138.5	0.1016	277.0	0.2031

* Below Analytical Sensitivity
N/A Not Analyzed

Table III

Asbestos Structure Concentration For Structures ≥ 5 µm
Project AAC807956

Sample #	Client Sample #	Analyzed Area (sq mm)	Sample Volume (liters)	Structure Counts		Analytical Sensitivity		Concentration	
				Chrysotile	Amphibole	(s/sq mm)	(s/cc)	(s/sq mm)	(s/cc)
CT1737	G-3C-54	0.0072	100.2	0	0	138.5	0.9123	<138.5*	<0.9123*
CT1738	G-4F-55	0.0144	900.0	3	0	69.3	0.0508	207.8	0.1524
CT1739	G-4C-56	0.0072	100.2	4	0	138.5	0.9123	554.0	3.6492

* Below Analytical Sensitivity

Appendix F

United States Environmental Protection Agency Model for Estimating Asbestos Concentrations From Unpaved Roads

PNL-7312
UC-630

GUIDANCE MANUAL ON THE ESTIMATION OF AIRBORNE ASBESTOS CONCENTRATIONS AS A FUNCTION OF DISTANCE FROM A CONTAMINATED ROADWAY FOR ROADWAY SCREENING

R. D. Stenner
J. G. Droppo
R. A. Peloquin
R. W. Bienert
N. C. VanHouten

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PREFACE

California's state rock, serpentine, is commonly used in the surfacing and maintenance of unpaved roads. Serpentine is a natural source of asbestos fibers. Asbestos fibers are suspended into the air, along with road dust, by vehicle traffic along these roads and as a result pose a potential health risk to exposed populations.

Over the past few years, the U.S. Environmental Protection Agency's (EPA's) Emergency Response Section for Region 9 has had to perform three Superfund removal actions involving roads surfaced with serpentine rock. During the course of these investigations, it became apparent that many similar roads may exist.

The Exposure Assessment Group at EPA Headquarters has supported the development of the AACES-RS computer code, which has been developed as a tool to screen and rank roads in order of potential importance by providing estimates of downwind asbestos air concentrations. These air concentrations are not to be used for risk analyses, because a causal relationship between fiber morphology and health effects has not yet been established and accepted by the EPA.

ACKNOWLEDGMENTS

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1. INTRODUCTION

This Guidance Manual provides a quantitative approach for estimating, for the purpose of screening/ranking, the airborne concentrations of asbestos from roads surfaced with asbestos-bearing serpentine rock. This manual identifies the procedures necessary for estimating screening-level airborne concentrations of asbestos in disturbed soils associated with roadways whose surfacing material contains asbestos fibers. The manual is to be used in conjunction with the Airborne Asbestos Concentration Estimator System-Roadway Screening (AACES-RS) computer code, also provided in the form of computer disks in Appendix D. Step-by-step user instructions for the AACES-RS computer code are provided in Section 3.

1.1. BACKGROUND

On the earth's surface, where natural or artificial exposed surfaces containing asbestos fibers occur, there is a potential for human inhalation of these fibers. Exposure to airborne asbestos structures requires suspension of these fibers into the air and their subsequent transport in the atmosphere to a receptor. During the transport process, the concentrations of airborne asbestos fibers will be reduced by atmospheric dispersion and removal processes. As a specific example, considerable concern has been expressed over California's state rock, serpentine, which is a common material used in surfacing and maintaining unpaved roads in California. Serpentine is composed primarily of hydrous magnesium silicate and is therefore a source of naturally occurring asbestos fibers. The application of serpentine rock on a roadway allows asbestos fibers to be suspended in the air, along with road dust, by vehicle traffic along these roads. The suspended dust/asbestos structures pose a potential health risk to exposed populations.

Asbestos structures can also be suspended into the air by a number of other mechanisms. These mechanisms are normally divided into wind erosion and mechanical surface disturbance. The potential for wind erosion depends mainly on the local wind climatology and surface characteristics. Suspension by surface disturbances depends both on the frequency of disturbances and on surface characteristics.

1.2. PURPOSE

The purpose of this manual and the AACES-RS code is to provide a means of assessing and ranking potential airborne concentrations of asbestos resulting from the suspension of asbestos fibers from road surfaces. In the past few years, the U.S. Environmental Protection Agency (EPA) has investigated several asbestos-covered roads, some requiring removal actions. During the course of these investigations, it became apparent that there may be many similar roads and other contaminated surface areas across the nation. To assess potential impacts from asbestos on these road surfaces, EPA needed a method to estimate, from a screening/ranking perspective, the airborne concentrations of the asbestos fibers with respect to various distances from these contaminated road surfaces.

1.3. SCOPE

This manual and the companion AACES-RS computer code address the need to be able to produce screening-level estimates (i.e., rough estimates for comparative site evaluations and decision-making) of the airborne asbestos concentration deriving from these roadways. The AACES-RS code serves as a tool to make rough estimates of average airborne asbestos concentrations derived from unpaved roads containing serpentine rock or other asbestos-containing materials. The AACES-RS code requires that the user provide a minimum of two input parameters: 1) silt content and 2) asbestos content of the roadway surface. The default site and meteorological conditions can be modified for an analysis that is more specific to the roadway being evaluated. The AACES-RS code is a tool for evaluating conditions in the vicinity of the roadway, at distances between approximately 3 m (10 ft) and 150 m (500 ft).

The AACES-RS computer code uses menus for program control. The main menu is displayed in the upper left corner of the screen, with the light bar indicating which item is currently selected. The up and down arrow keys are used to move between items. Help can be obtained throughout an AACES-RS run either by moving the light bar to the help option or by pressing the F1 function key.

2. AIRBORNE ASBESTOS CONCENTRATION ESTIMATOR SYSTEM-ROADWAY SCREENING (AACES-RS) COMPUTER CODE

The AACES-RS computer code is designed to evaluate the average airborne asbestos concentrations derived from unpaved roadways whose surfaces are contaminated with asbestos. Such roadways include those where serpentine rock has been used as the gravel for the road surface. The AACES-RS code requires that the user provide a minimum of two input parameters: 1) silt content and 2) asbestos content of the roadway surface. However, a user who wants a screening analysis that is more specific to the situation being evaluated can modify other site specific inputs. Comparisons may be made for either a selected set of ambiant conditions or for average site conditions. The roadway model used in the AACES-RS code assumes that the wind direction always crosses the road surface toward the receptor. The AACES-RS code is applicable for evaluating conditions only in the vicinity of the roadway. Its range of applicability is for estimating concentrations at distances between approximately 3 m (10 ft) and 150 m (500 ft) from the roadway.

2.1. GENERAL STRUCTURE OF THE AACES-RS CODE

A flow diagram of the AACES-RS code, showing the general structure and most common flow path through the code, is provided in Figure 2-1.

2.2. AACES-RS OPERATIONAL METHODOLOGY

The AACES-RS code is designed to be user friendly. Operations are selected from the main menu and several submenus. Parameters are presented with explanatory text in a series of Help screens. The AACES-RS code allows the user considerable flexibility in choosing the route through a run. However, there is a default flow path, as shown in Figure 2-1, which will automatically lead users (unless they choose otherwise) through the various steps,

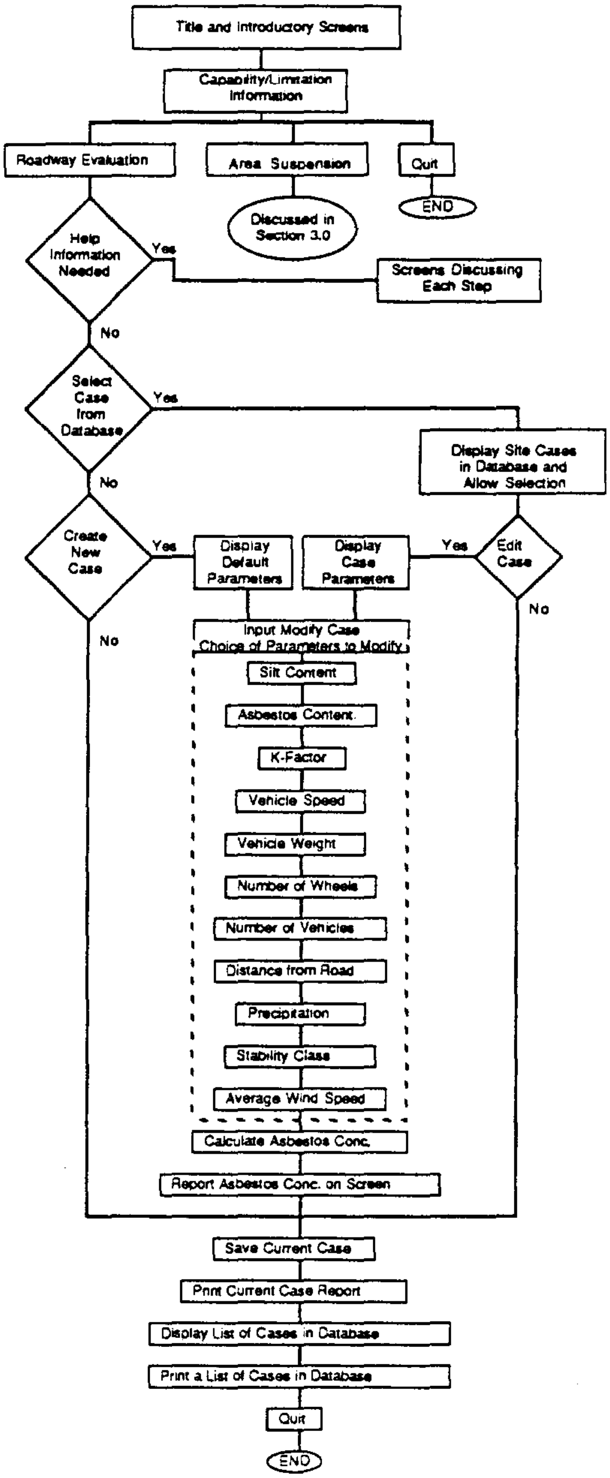

Figure 2-1. Flow chart illustrating the common flow path for the AACES-RS computer code.

store the input and output information in an internal database, and provide a printed report for each run (i.e., case).

The internal database allows the user to track runs by site name and case number. The site name should be kept the same for all runs made for a site, because the AACES-RS code will record all the information associated with an individual site under that common site name. The case number allows the tracking of separate runs that are made to examine different conditions and/or assumptions at an individual site.

In the development of the AACES-RS code, two candidate models for estimating asbestos suspension from unpaved roadways were identified. The two models considered were the Copeland Model (EPA, 1985) and the Cowherd Model (Cowherd et al., 1984). The Copeland and Cowherd models are very similar in their formulation; the primary difference is in the magnitude of exponents. The two models were compared to determine if one was clearly superior to the other, but they appeared to provide comparable predictive performance. For continuity with the California Environmental Asbestos Roads Study, the Copeland model was chosen as the base model to modify and use in the AACES-RS computer code.

Because a model was needed for predicting asbestos air concentrations at various distances from roads, an atmospheric dispersion and transport component enhancement was added to the Copeland Model. A workbook for making atmospheric dispersion and transport calculations has been developed by Turner (1969). Turner's dispersion parameters and formulation for a Gaussian line-source emission were used to derive an expanded air-concentration version of the Copeland Model. This new version of the Copeland Model includes wind speed and atmospheric stability as variables rather than as constants. This expanded version also resolves questions of unit consistency that had been raised regarding the

Copeland Model. The expanded version of the Copeland Model was developed for two reasons: First, it was felt that the unpaved-roadway asbestos model should be able to account for local climatological conditions and to provide concentration estimates for distances other than a single fixed distance from the roadway. A single fixed distance would not allow the evaluator to account for normal receptor distance from the roadway, which might be a critical factor in setting priorities and making decisions on actions among sites being evaluated. Second, consideration of wind speed and stability was needed to allow study of special cases. Wind speed and stability are also important for comparisons with measured values at various distances from the roadway.

The Expanded Copeland Model is presented in the following paragraphs by component development to show how it was developed for use in the AACES-RS code.

2.2.1. Copeland Emission Equation

The emission form of the Copeland Model has been given by EPA (1985, page 11.2.1-1) as

$$E = 1.7\ k\ \frac{S}{12}\ \frac{V}{48}\ \left(\frac{W}{2.7}\right)^{0.7}\ \left(\frac{WH}{4}\right)^{0.5}\ \frac{(365-p)}{365} \tag{2-1}$$

where E = emission rate, kg/VKT (VKT=vehicle-km traveled)

k = aerodynamic particle-size multiplier (range of 0.8 to 0.095)

S = silt content of roadway (percent of road surface material passing through a 200-mesh screen)

V = vehicle speed, km/h

W = vehicle weight, Mg (Mg = megagrams = 10^6 g)

WH = number of wheels per vehicle

p = number of days with greater than 0.25 mm (0.01 in.) of precipitation.

To derive an expression for air concentrations, the first step is to relate the total distance traveled (on an arbitrary segment of the roadway) to traffic and roadway parameters using the equation

$$D = n\,L\,t \tag{2-2}$$

where D = total distance traveled over the segment, VKT

n = vehicle frequency, #/s

L = length of roadway traveled by each vehicle, km

t = duration of emissions, s.

Next, the roadway emission rate is expressed as emissions per length of road per time

$$Q = \frac{E\,D}{L\,t} \tag{2-3}$$

where Q is the emission rate, g/m per s. Combining Equations (2-1), (2-2), and (2-3) gives

$$Q = 1.7\ k\ n\ \frac{S}{12}\ \frac{V}{48}\left(\frac{W}{2.7}\right)^{0.7}\left(\frac{WH}{4}\right)^{0.5}\frac{(365-p)}{365} \tag{2-4}$$

Equation (2-4) is an intermediate version of the Copeland Model that expresses emissions in a form appropriate for use in an atmospheric line-source transport and dispersion application.

2.2.2. Atmospheric Dispersion and Transport

Turner (1969) gives an equation for a line source that, for a ground-level release, reduces to

(2-5) $$C = \frac{2}{(2\ \pi)^{0.5}} \frac{Q}{\sigma_z\ U}$$

or

(2-6) $$\frac{C}{Q} = \frac{2}{(2\ \pi)^{0.5}\ \sigma_z\ U}$$

where C = the air concentration, g/m^3

σ_Z = the vertical dispersion parameter, m

U = the wind speed measured at about a 2-m height, m/s.

Along a roadway, two major factors determine the value of the vertical dispersion parameter for dust suspended by a passing vehicle. First, dispersion by the vehicle wake provides an initial dispersion for the suspended material. Second, ambient atmospheric turbulence will further dilute the plume as it is carried by wind.

A relatively simple wake model was selected for the climatological application of characterizing the initial wake of the vehicle and combining this initial dispersion with the ambient dispersion. The vertical dispersion parameter is computed from the relationship

(2-7) $$\sigma_Z = (\sigma_Z'^2 + H^2)^{0.5}$$

where σ_Z' is the ambient vertical dispersion parameter (m) and H is the estimate of initial vertical dispersion of the vehicle wake (m).

The inclusion of the parameter for initial vertical dispersion of the vehicle wake is required for computations very near the roadway. At distances on the order of a few tens of feet, dispersion will normally be dominated by the vehicle wake. Use of the ambient vertical dispersion parameter formulations is normally recommended for applications no closer than a few hundred feet from the release. The use of the σ_z relationship at shorter distances represents an extrapolation to link the initial and ambient dispersion processes.

The value of H will mainly be a function of the characteristics (i.e., height, length, and speed) of the vehicles traveling over the roadway. As an approximation, H should be set equal to about 50% of the average vehicle height.

2.2.3. Asbestos Concentrations from Roadway

The air concentration of particulate matter (g/m^3) is converted to asbestos concentration ($structures/m^3$) using the equations

$$A = \frac{C}{Q} \frac{AC}{100} Q \ CF \tag{2-8}$$

where A = asbestos concentration, structures/m^3

CF = conversion factor* = 3×10^{10}, structures/g

AC = asbestos content of road surface silt component, %

and

$$A = \left(\frac{2}{(2 \pi)^{0.5}}\right) \left(\frac{1}{\sigma_z U}\right) \frac{AC}{100} Q \ CF \tag{2-9}$$

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*The conversion factor of 3×10^{10} is an average value taken from the open literature. This average value is assumed to represent all fiber lengths, although it may only be accurate as an average for a specific size range of fibers (e.g., fibers >5 mm in length).

Finally, using Equation (2-4) the result is

$$A = 1.7\ k \left(\frac{2}{(2\ \pi)^{0.5}}\right) \frac{S}{12}\ \frac{V}{48} \left(\frac{W}{2.7}\right)^{0.7} \left(\frac{WH}{4}\right)^{0.5} \frac{AC}{100}\ \frac{n}{\sigma_z}\ \frac{CF}{U}\ \frac{365-p}{365} \tag{2-10}$$

This equation comprises the Expanded Copeland Model.

The Expanded Copeland Model, as used by the AACES-RS code, is designed assuming that variables are expressed in metric units. However, because metric units are not the most common units used by the general public in the United States, the AACES-RS code requests the information in terms of common units and makes the appropriate conversion for each variable affected.

2.2.4. Default Values

Unless changed by the user, the AACES-RS code uses typical values as defaults. The initial run for each site (i.e., case 1) is automatically a run with site-specific input for only asbestos content and silt content and with all other parameters held at default values. This is done to provide a standard case situation from which to begin the comparison of the level of contamination at one site with the levels of contamination at other sites. The individual default parameters are discussed by parameter in the paragraphs that follow.

2.2.4.1. Particle-Size Multiplier (k-factor)--The default value used for the particle-size multiplier (k) is 0.36. In accordance with Section 11.2 of AP-42 (EPA, 1985), the particle-size multiplier varies with aerodynamic particle-size range, as shown in Table 2-1. The default value was set at 0.36 because this is the particle-size multiplier for a particle-size cutoff point of ≤ 10 μm, and the ≤ 10-μm particle-size range is commonly used when considering respirable particulate matter.

TABLE 2-1. AERODYNAMIC PARTICLE-SIZE MULTIPLIERS FOR UNPAVED ROADWAYS

Particle-size range, µm	Particle-size multiplier (k)
≤30	0.80
≤15	0.50
≤10	0.36
≤5	0.20
≤2.5	0.095

2.2.4.2. Vehicle Speed--The default value for the average vehicle speed is 48 km/h (30 mph). This value was established using information obtained from a fugitive dust study conducted by Cowherd and Guenther in the St. Louis area (Cowherd and Guenther, 1976). Based on driver interviews, they established that the average vehicle speed on unpaved roads in the St. Louis area is 48 km/h (30 mph).

2.2.4.3. Vehicle Weight--The default value for the average vehicle weight is 1.6 Mg (1.8 tons). This value was established assuming that the average weight of a full-sized car or pickup with a normal load of people and materials would be approximately 3,600 lb (1.8 tons).

2.2.4.4. Number of Wheels--The default value for the average number of wheels per vehicle is four. The assumption was made that the average vehicle using the unpaved roads being evaluated would be a regular passenger vehicle (i.e., automobile or pickup truck).

2.2.4.5. Vehicle Frequency (Number of Vehicles)--The default value for the average number of vehicles is 2 x 10^{-3} vehicles/second, which is approximately

76 vehicles per day averaged over a calandar day with an active period of 11 hours. This value of 76 vehicles per day (approximately 7 vehicles/hour on an active hourly basis) was established using information taken from a study conducted by Cowherd and Guenther (1976) in the state of Illinois. The data in the study showed an average annual daily traffic (ADT) of approximately 76 vehicles per day (based on an 11-hour day, from 6 am to 5 pm). The default vehicle frequency value of 76 vehicles per day (7 vehicles per hour) is environmentally conservative in that it is the number of vehicles averaged over only the active period of a day. It should be pointed out that this default vehicle frequency value is only a rough estimate established to provide baseline guidance from which to examine asbestos concentrations among sites. Although the actual number of vehicles per second or per hour may vary considerably at different hours of each day, the model requires input of the average frequency. The user should obtain traffic count data, generally available from most county and state highway departments, to more accurately account for the actual traffic pattern on the roadway being evaluated.

2.2.4.6. Vertical Dispersion Parameter (σ_Z)--Along a roadway, two major factors determine the value of the vertical dispersion parameter for dust suspended by a passing vehicle. First, dispersion by the vehicle wake provides an initial dispersion for the suspended material. Second, ambient atmospheric turbulence will further dilute the plume as it is carried by the wind. A relatively simple wake model was selected for the climatological application of characterizing the initial wake of the vehicle and combining this initial dispersion with the ambient dispersion. The vertical dispersion parameter is calculated using Equation (2-7). The ambient vertical dispersion parameter ($\sigma_{Z'}$) used in the AACES-RS code is taken from a series of equations developed by Martin and Tikvart (1968) that express $\sigma_{Z'}$ according to stability class and distance from the roadway. An H value of 1 m was selected as a first approximation to account for the dispersion caused by the vehicle wake. Comparisons with field data suggest a value for H between 0.5 m and 1.0 m for passenger vehicles. Equation (2-7) is used by the AACES-RS code to calculate σ_Z. The vertical dispersion parameter for passive atmospheric processes is computed using the equation

$$\sigma'_z = A\, d^B + C \tag{2-11}$$

where A, B, and C are constants as defined in Table 2-2, and d is downwind distance. The break at 100 m in Table 2-2 is an arbitrary point chosen for curve-fitting and does not imply any special accuracy in these relationships.

TABLE 2-2. CONSTANTS FOR VERTICAL DISPERSION PARAMETER

Stability class	Distance $\leq$100 m A	B	C	Distance >100 m and <153 m A	B	C
A	0.192	0.936	0.0	0.00066	1.941	9.27
B	0.156	0.922	0.0	0.0382	1.149	3.3
C	0.116	0.905	0.0	0.113	0.911	0.0
D	0.079	0.881	0.0	0.222	0.725	-1.7
E	0.063	0.871	0.0	0.211	0.678	-1.3
F	0.053	0.814	0.0	0.086	0.74	-0.35

2.2.4.7. Distance from Road--The default value for the distance from the roadway being evaluated is 15 m (50 ft). This default value has been selected as a typical distance for the modeling system to address.

2.2.4.8. Precipitation Days--The default value for the number of precipitation days (p) is 60 days of precipitation per year. This default value was selected as a typical number of precipitation days for the area of California where roads with an asbestos problem typically occur.

2.2.4.9. Stability Class--The default entry is D atmospheric stability, representing average atmospheric conditions. Since the AACES-RS code is designed to provide an estimate of average exposures, any deviation from Class D stability should be based on an evaluation of local road usage. At most sites, the stability conditions will be a function of the time of day and of local traffic patterns, which may reflect a preferred set of stability conditions. Table 2-3 provides guidance on the variations of stability as a function of time of day, winds, and solar radiation.

2.2.4.10. Average Wind Speed--The average wind speed may either be a wind speed selected as a case-study, or be an average speed that is representative of the site. For the latter, the input wind speed should ideally be computed as average inverse wind speeds reflecting the use of inverse wind speed in the dispersion computation. For most purposes, the average wind speeds as reported in a Local Climatic Data (LCD) Summary for a location in the same region as the site will be sufficient. These LCD summaries are available for the entire United States. For the Central Valley of California, typical values are 2.8 m/s for Fresno; 3.7 m/s for Sacramento; and 3.9 m/s for Red Bluff (NOAA, 1978).

2.2.4.11. Vehicle Wake Vertical Dispersion--The vertical vehicle wake parameter (H) is an estimate of the initial vertical dispersion of material suspended by the vehicle wake. At distances on the order of a few tens of feet, dispersion is dominated by the vehicle wake. Therefore, the value of H will mainly be a function of the characteristics (i.e., height, length, and

TABLE 2-3. GENERAL STABILITY CLASS INFORMATION[a]

Stability class	Time	Wind condition	Wind, mph	Solar radiation
A	Day	Very light	<5	Strong
B	Day	Very light	<5	Moderate to light
B	Day	Light	5-7	Strong to moderate
C	Day	Light	5-7	Light
B	Day	Moderate	7-11	Strong
C	Day	Moderate	7-11	Moderate to light
C	Day	Windy	11-13	Strong
D	Day	Windy	11-13	Moderate to light
C	Day	Strong	<13	Strong
D	Day	Strong	>13	Moderate to light
E	Night	Light	5-7	50% cloud cover to overcast
F	Night	Light	5-7	<50% cloud cover
D	Night	Moderate	7-11	50% cloud cover to overcast
E	Night	Moderate	7-11	<50% cloud cover
D	Night	Windy to strong	>11	Any cloud cover condition

[a] Conditions are listed in order of ascending wind speed and decreasing solar radiation.

speed) of the vehicles traveling over the roadway. As an approximation, H should be set at approximately 50% of the average vehicle height. A default value of 1 m is provided for the user who has no means of determining the average vehicle height for computing the 50% value.

2.2.5. Modification of Default Values

As mentioned earlier, the initial run of the AACES-RS code for each site (i.e., case 1) is automatically run with site-specific input for only asbestos content and silt content and with other parameters set at the default values. This provides a standard case situation with which to begin the analysis. However, a user should use cases with site-specific input in place of default data values whenever possible to determine the need for action and to set priorities. The standard case (i.e., case 1) is created only to provide a common starting point from which to examine the modifications made in the other case runs, the differences among users applying the AACES-RS code to the sites, and the differences among sites at different locations.

A sensitivity analysis was conducted on the model used in the AACES-RS code to assist in determining which parameters are most sensitive (i.e., have the greatest impact on the results). The sensitivity analysis examined the response of the model when the parameters were at extremes. Two methods for sensitivity analysis were employed. In the first, the model outputs were compared for default and extreme data configurations. The results from this method provide an indication of the range of model predictions that can be obtained from various data configurations (i.e., this method addresses global change considerations). In the second method, the partial derivatives with respect to the input parameters were computed (i.e., this method addresses local change considerations). The partial derivatives can be used to put the input variables in order according to their influence on the model, considering a base set of variable conditions.

The series of curves shown in Figures 2-2 through 2-8 show the variability of the predicted asbestos concentration as it is related to the variability of the different evaluation parameters (i.e., evaluation parameters other than silt content, asbestos content, average wind speed, and distance from the roadway). The silt content and asbestos content are the two required site-specific inputs and should be determined as accurately as possible. The average wind speed is a significant parameter and should be obtained using the climatological data summary from a local weather station (e.g., at a local airport). The distance from the roadway is an input choice allowing the user to estimate concentrations at the point of exposure concern. The curves presented in Figures 2-2 through 2-8 are provided to allow the impact that each parameter has on the resulting asbestos concentration to be examined so that a more informed decision can be made regarding which parameters, if any, have the most effect in the range of interest.

The partial derivatives were used to put the evaluation parameters (i.e., variables) in order according to their influence on the model results, considering a base set of variable conditions. The partial derivatives are interpreted as representing the amount that the asbestos concentration results will change given a unit change in the evaluation parameter. Thus, variables with large-magnitude partial derivatives have more influence on the model than variables with partial derivatives having small magnitudes. A negative sign associated with the derivative means that the predicted asbestos concentration will decrease as the value of the parameter increases; a positive sign for the derivative means that the predicted asbestos concentration will increase as the parameter value increases. The default values and partial derivatives of the

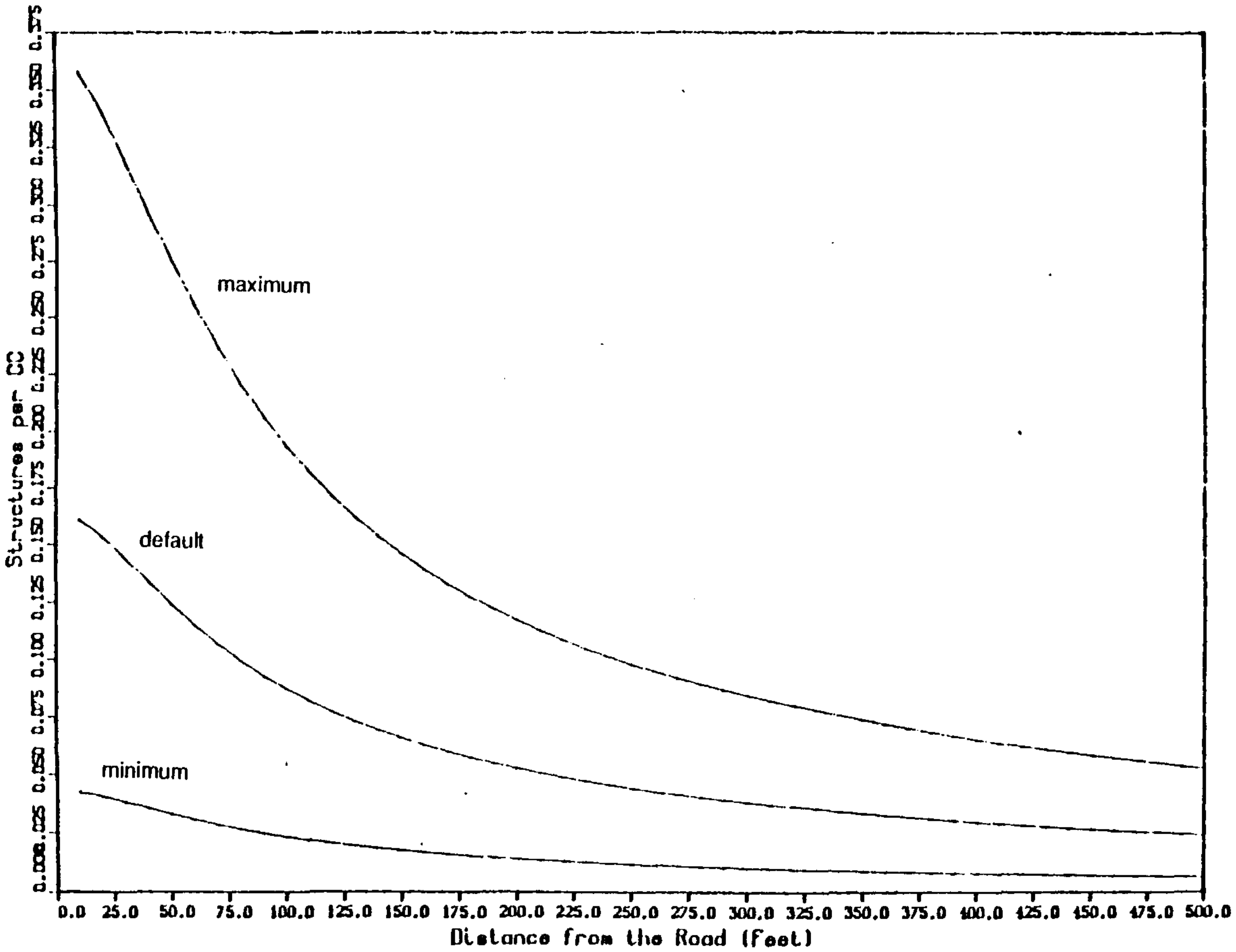

Figure 2-2. Graph showing asbestos air concentrations for extreme values of the k-factor (i.e., particle-size multiplier).

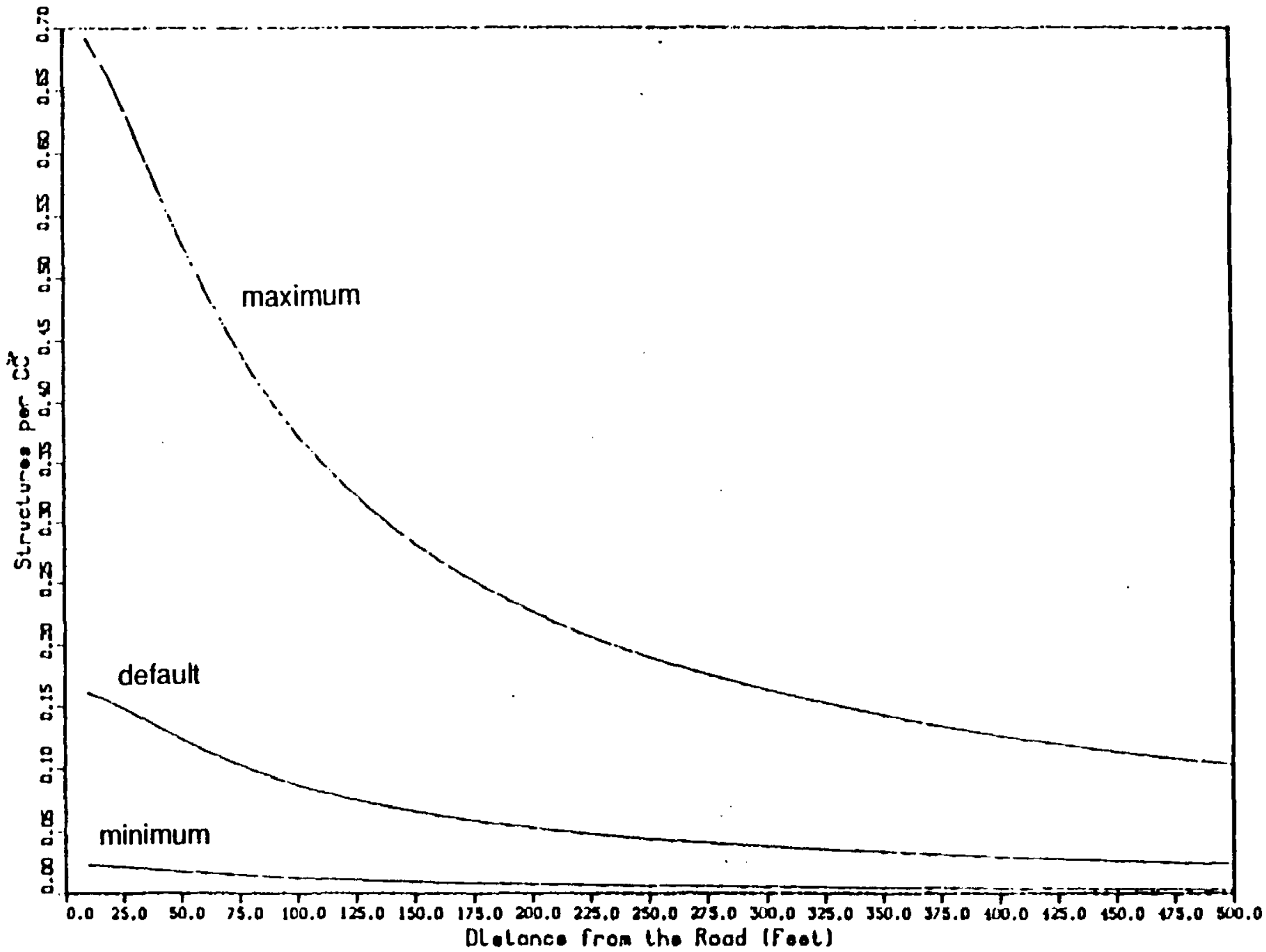

Figure 2-3. Graph showing asbestos air concentrations for extreme values of n (i.e., vehicle frequency).

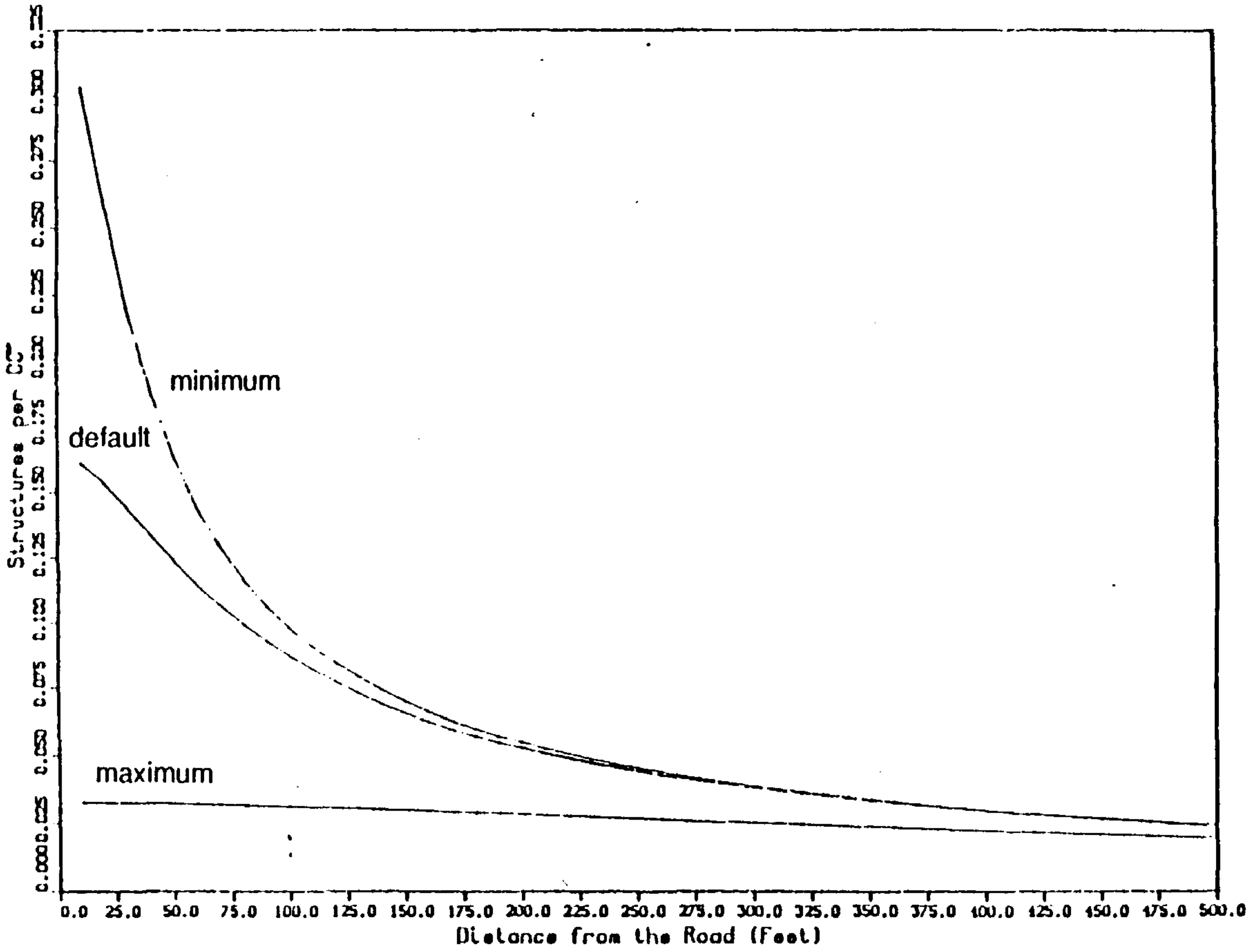

Figure 2-4. Graph showing asbestos air concentrations for extreme values of H (i.e., initial vertical dispersion of the vehicle wake).

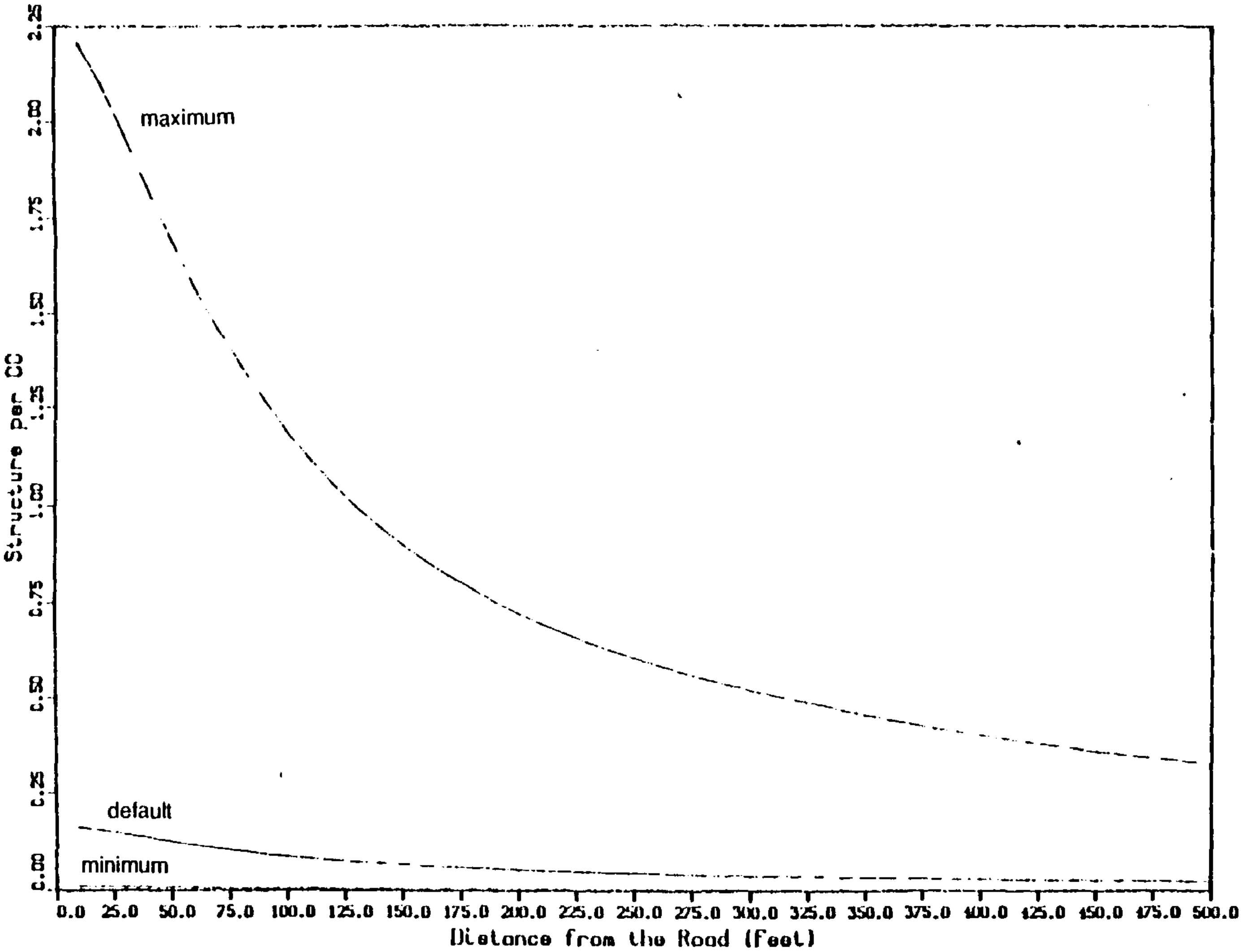

Figure 2-5. Graph showing asbestos concentrations for extreme values of vehicle weight and number of wheels.

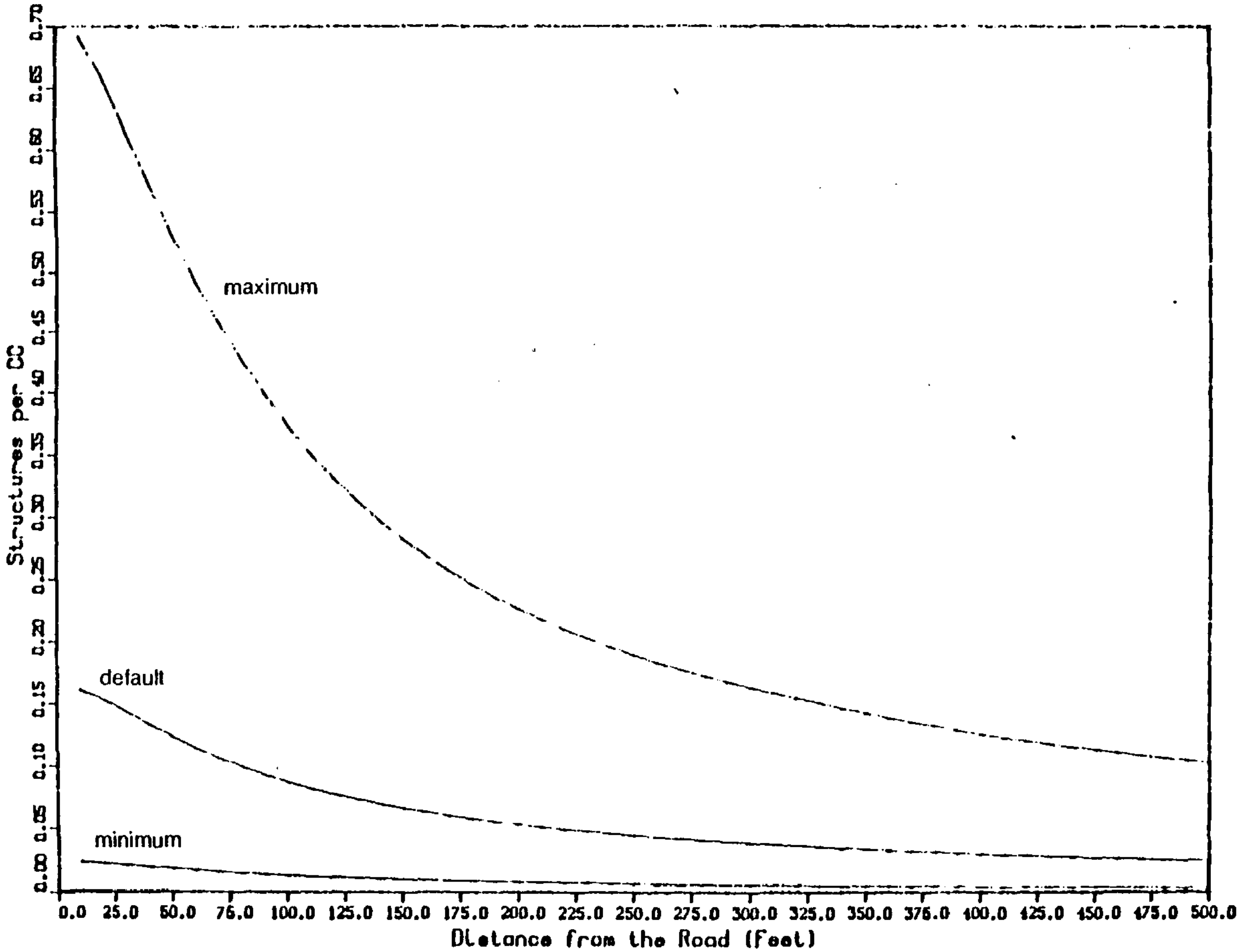

Figure 2-6. Graph showing asbestos air concentrations for extreme values of number of vehicles.

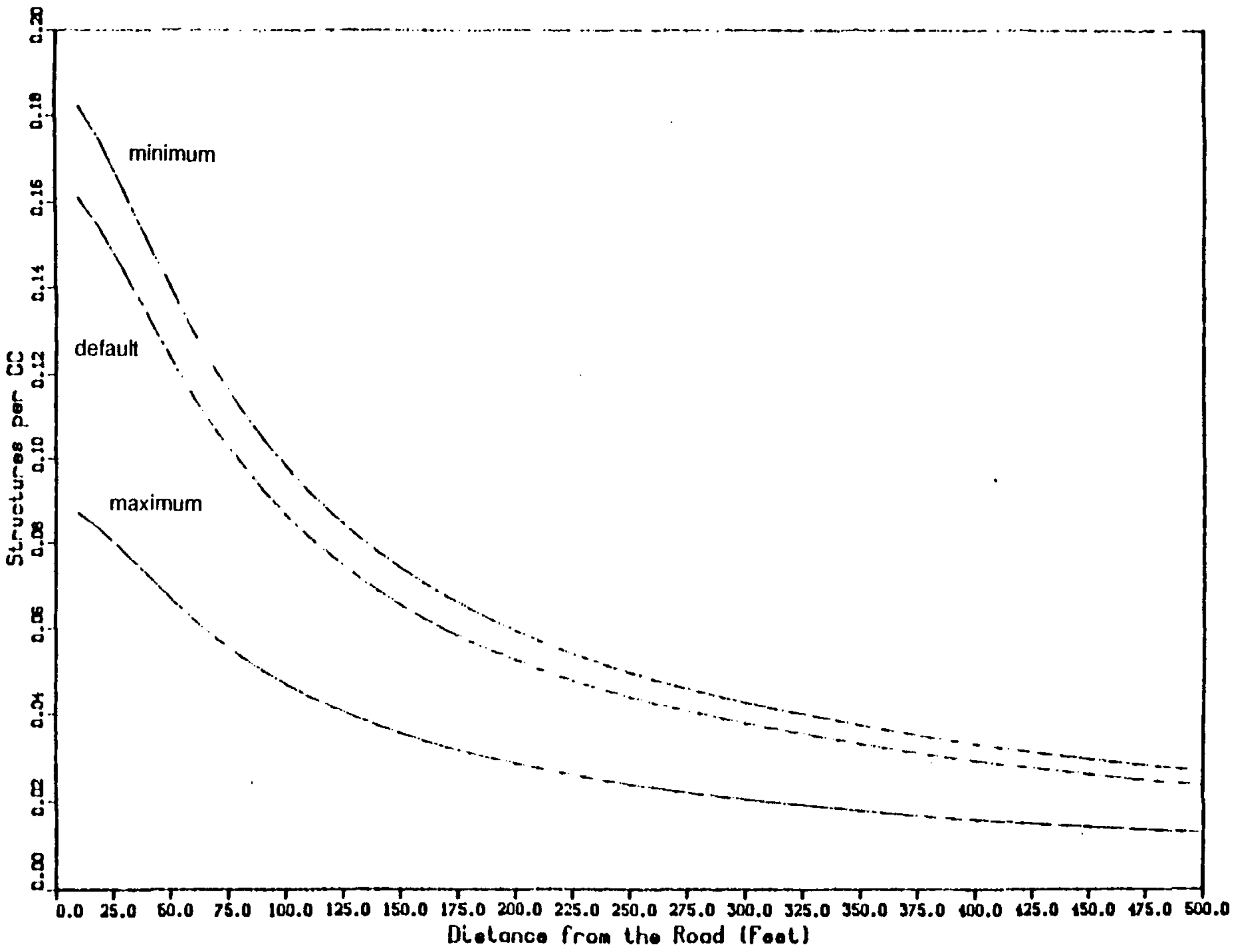

Figure 2-7. Graph showing asbestos air concentrations for extreme values of number of days with 0.254 mm (0.01 in.) of precipitation per year.

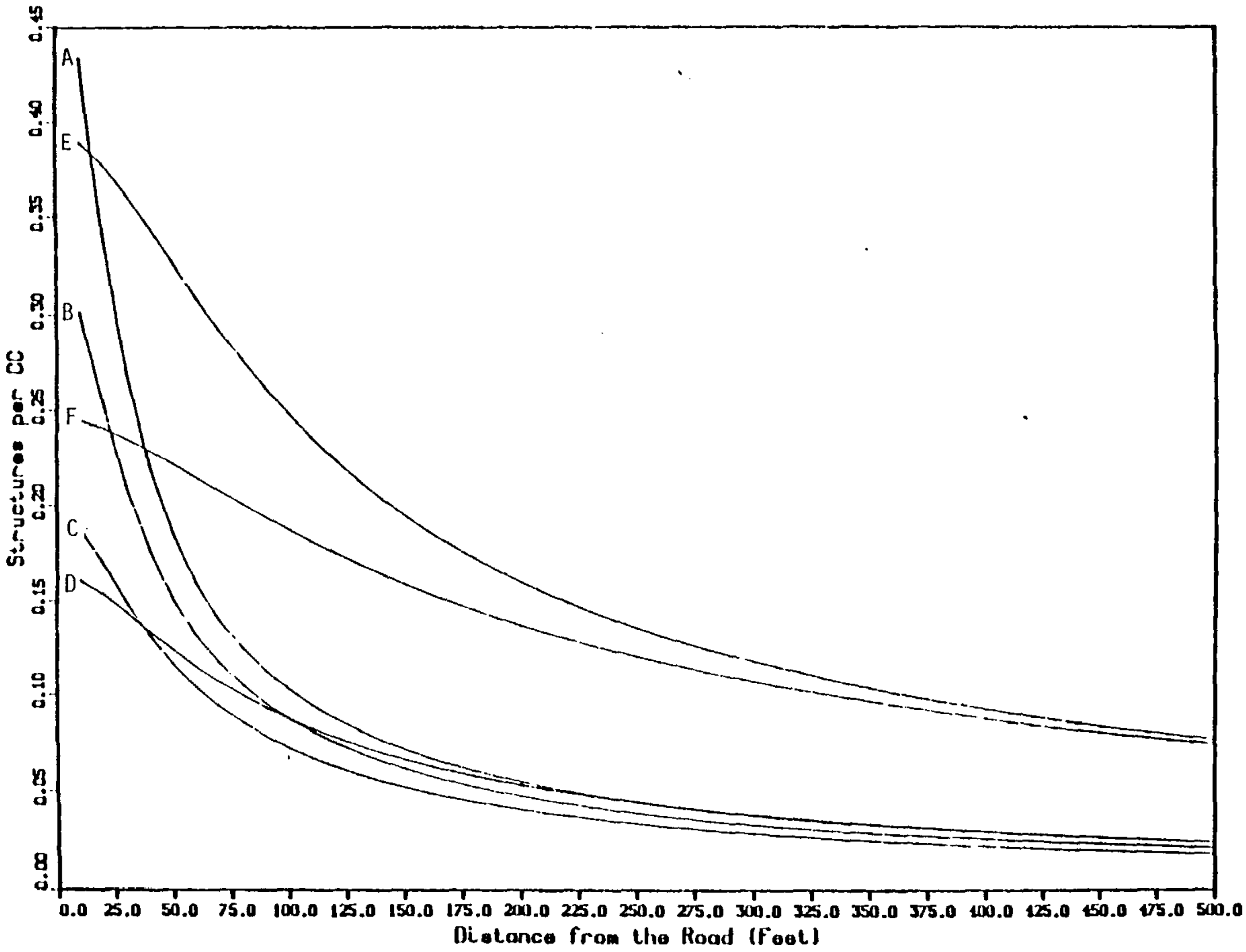

Figure 2-8. Graph showing asbestos concentrations for atmospheric stability classes.

evaluation parameters are shown in Table 2-4. The partial derivatives presented in Table 2-4 are provided to allow the impact that each parameter has on the resulting asbestos concentration to be examined, so that a more informed decision can be made regarding the data needed for input parameters (e.g., number of vehicles has most impact, then the k factor, and so on).

2.2.6. Calibration of AACES-RS Roadway Model

The AACES-RS code was calibrated to data that were collected as part of the California Environmental Asbestos Roads Study, as specifically requested by the EPA. Therefore the AACES-RS code was calibrated to the ≥ 5-μm data, as measured by Transmission Electron Microscopy (TEM) method, of the California Environmental Asbestos Roads Study.

TABLE 2-4. PARTIAL DERIVATIVES OF ROADWAY MODULE PARAMETERS

Parameter	Default value	Partial derivative
Number of vehicles	0.00194	6.40E+01
k-factor	0.36	3.59E-01
Vehicle weight	1.6	5.43E-02
Asbestos content	4	3.10E-02
Average wind speed	6	-2.07E-02
Number of wheels	4	1.55E-02
Silt content	18	6.90E-03
Vehicle speed	48	2.58E-03
Distance from road	50	-9.43E-04
Precipitation days	60	-4.07E-04

This roadway study was conducted for one special set of conditions in California. Comparing the model predictions with the field data provides a test of the model for this one set of conditions. In addition, values may be estimated from this test for certain of the model parameters.

The parameters that were fixed for each study period include 1) the vehicle weight, number of wheels, speed, and frequency of passage, 2) the wind direction (approximately perpendicular to the roadway), 3) meteorological dispersion conditions (daytime with low wind speeds), and 4) the roadway surface composition.

It was not possible to exactly define the stability for each study period, because specific atmospheric stability information was not collected. However, the conditions selected for study were clearly those typical for relatively rapid dispersion rates (i.e., unstable conditions). This was indicated by several things. First, data were all collected under low wind conditions during daytime hours. Second, the topography of the field site was such that the wind direction was normally perpendicular as a result of a local thermally driven upslope air flow, clearly indicating unstable atmospheric conditions. Hence, the assumption was made for the comparison that all tests were conducted under unstable atmospheric conditions.

Asbestos concentrations were computed using Equation 2-10 for comparison with the one-hour TEM analysis asbestos structures (PCM equivalent by size; TEM_TCO) data points. Measured data with a "<" designation were not used in the comparison. Tests indicated that the inclusion of these less certain data would not have changed the results of the comparison. The one-hour data points were taken at downwind distances of 10, 25, and 50 ft.

There was only one TEM_TCO eight-hour data point without the "<" designation, and the periods represented coincided with some of the one-hour data. Therefore, the eight-hour data values were not used in the comparison.

Most of the model input parameters were assumed to have fixed values. The average polarized light microscopy (PLM) analysis percent of asbestos by area (PLM_CAP) value of 2.3% for the percent asbestos in the roadway was used. A value of 13.4 was used for average silt content based on the analysis of the roadway surface material samples. The vehicle parameters used were a frequency of 4 per hour, a weight of 1.2 tons, an average of 4 tires, and a speed of 48.3 km/hr. A range of unstable atmospheric dispersion conditions, based on Pasquill categories of A, B, and C, was considered.

Given that the database contained information on wind direction and wind speed, case-specific values of these parameters were used to compute asbestos concentrations. Average wind speeds for the measurement period were used directly in the computation of asbestos air concentrations. The wind direction entered into the computation of the vertical dispersion parameter as a correction factor for the distances traveled by the plume between the roadway and the sampler locations.

$$x' = x / \cos(DEV) \quad (2\text{-}12)$$

where x' = distance traveled by plume, m

x = distance of sampler from roadway, m

DEV = wind direction's deviation from perpendicular path, degree.

The AACES-RS model has two situation-specific parameters: the initial dispersion length (H) and the fraction of soil material suspended in the size range of interest (k). The initial dispersion length is a function of the turbulence generated by the vehicle. For soil suspension, the table in AP-42 (EPA, 1985) implies a value of 0.6 for the value of k for particles in the range of 5 μ to 30 μ. This value of k corresponds to the size range for TEM_TCO.

A combination of H and k values was selected that gave a good fit to both the absolute magnitude and the rate of concentration decrease with distance from the roadway. Stability category B was used as a basis of comparison.

Figure 2-9 shows a comparison of the average TEM_TCO concentrations with concentrations computed for stability classses A, B, and C. The match of slope and magnitude in this plot resulted from using k = 0.4 and H = 0.7. Figure 2-10 shows a comparison of the individual measured data points and those computed from B stability.

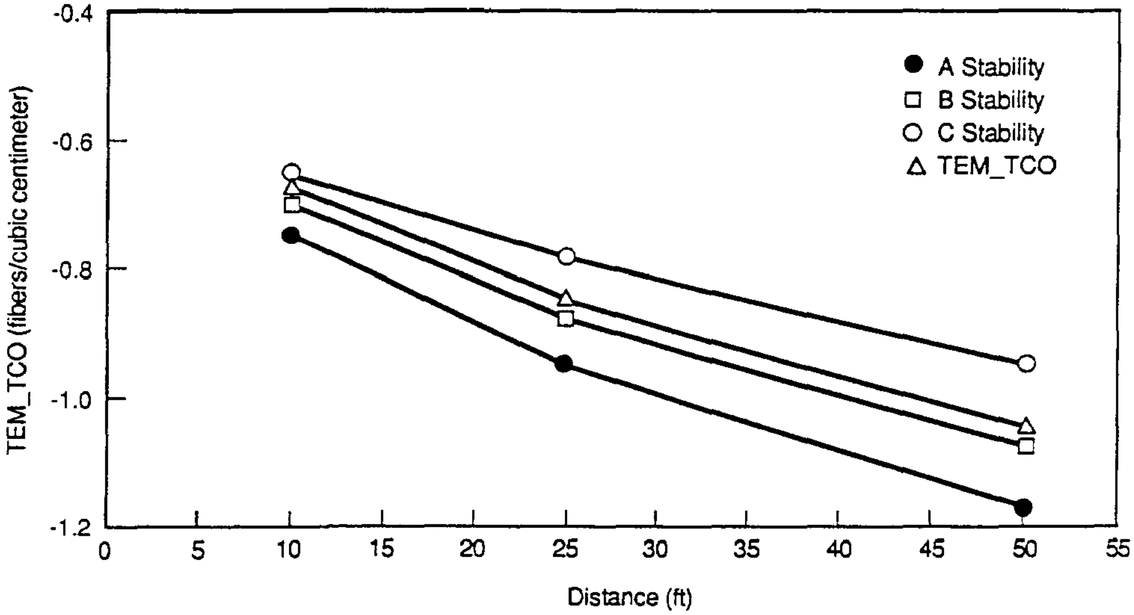

Figure 2-9. Comparison of average measured TEM_TCO with computed value.

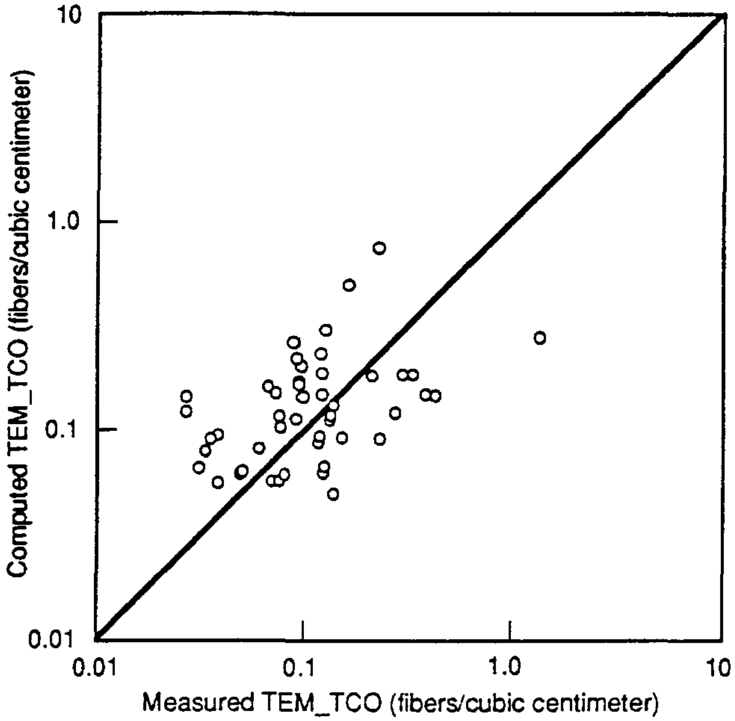

Figure 2-10. Comparison of measured TEM_TCO value with value computed for B stability category.

The narrow range of conditions covered by the field data limited the extent to which various portions of the model could be calibrated. Allowing for the scatter in the results, reasonable agreement between the computed and measured data could be obtained for H values in the range from 0.5 to 1.0 m and for k values between 0.2 and 0.8.

This calibration did not significantly improve the model. Even without calibration using the roadway data, the model will predict asbestos concentration to an order of magnitude. The fact that these values are within the range that would normally be selected for an application lends credibility to model formulation. The narrow range of study conditions and uncertainties in the stability conditions limit the opportunity for additional comparisons or calibrations. The model has been shown to perform well under the meteorological conditions and vehicular traffic patterns of the field study. It has not been evaluated, validated, or calibrated for a full range of meteorological, traffic, or roadbed conditions.

2.3. USE AND INTERPRETATION OF AACES-RS RESULTS

The AACES-RS code is primarily designed to provide a common means of estimating the localized airborne asbestos concentration associated with unpaved roads surfaced with serpentine rock. It is a tool designed to estimate such concentrations within a range of 3 to 150 m (10 to 500 ft) from a roadway.

The AACES-RS code is intended to provide a uniform and consistent basis from which to screen and prioritize the seriousness of airborne asbestos problems at roadway sites containing serpentine rock. The code is designed for the primary use of performing comparative evaluations between sites with serpentine-rock-associated airborne asbestos concentrations. Using the AACES-RS code in this manner will allow the screening and prioritizing of these sites. However, care should be taken in how the asbestos concentrations estimated by the AACES-RS are used. These concentrations are estimated from generalized site conditions. Point-in-time airborne asbestos concentrations at a site may vary considerably, depending on immediate site conditions, and the AACES-RS was not designed to evaluate such conditions (see Section 2.4 for a discussion of AACES-RS limitations).

The AACES-RS code should not be used in a public risk-assessment process, because it assumes average conditions and produces only average concentration results. It was purposely designed this way to limit the type and amount of input necessary to produce estimated concentrations for screening and ranking purposes.

2.4. AACES-RS CODE LIMITATIONS

The AACES-RS code is intended to serve only as an easy-to-use system that provides a rough screening estimate of the typical hourly airborne asbestos concentrations from a roadway contaminated with asbestos. The following limitations inherent in the code must be recognized:

- The estimates of downwind asbestos air concentrations calculated by AACES-RS are to serve as rough estimates for use in assessing site-specific risks, and are not to be used for specific risk analysis.
- The model assumes the wind direction is always across the road surface toward the receptor. This is not necessarily always the wind direction that will yield the maximum downwind concentration of asbestos. The most limiting case is that of a long straight roadway with winds nearly parallel to the roadway.
- The model assumes average conditions and produces typical asbestos concentration results.
- The model makes no allowances for particle deposition.
- Health impact and particle behavior issues regarding asbestos particle sizes are still unresolved. Once the issues have been resolved, adjustments for effective particle size should be made to the model.
- Issues regarding the state-of-the-art techniques for asbestos sampling and analysis are still unresolved. The model requires, as a primary input parameter, the asbestos content of the roadway in question.
- The model assumes that the roadway is straight and infinitely long and that its elevation is equal to that of the receptor.
- The predictive validity of the AACES-RS code may be overextended in cases where more time consuming and costly assessment measures are implicated.

REFERENCES FOR CHAPTER 2

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Cowherd, C.; Muleski, G.E.; Englehart, P.J.; Gillette, D.A. (1984) Rapid assessment of exposure to particulate emissions from surface contamination sites. Prepared for the U.S. Environmental Protection Agency, Office of Air and Radiation, Research Triangle Park, North Carolina.

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3. AACES-RS USER'S MANUAL

The AACES-RS code is designed to operate on IBM* or compatible microcomputers using a hard-disk storage system. If the AACES-RS code will be used to evaluate several sites, a hard-disk system will be more efficient, because the AACES-RS code maintains a database containing all the input parameters as well as results.

3.1. AACES CODE INSTALLATION

Section 3.1 discusses the elements necessary to install and set up the AACES-RS code.

3.1.1. Computer Implementation

The following subsections concern transfer package contents, minimum computer system requirements, and installation of the AACES-RS software package on a computer.

3.1.1.1. AACES-RS Transfer Package Contents--The AACES-RS software is distributed on a double-density 5.25-in. floppy disk formatted under DOS 3.1 for the IBM personal computer or compatible microcomputers.

3.1.1.2. Minimum Computer System Requirements--The current version of the AACES-RS software package was designed to execute on the IBM PC/XT/AT/PS2 computer operating under IBM DOS 3.1 (or a newer version of DOS). The computer must be configured with a minimum of 512 kilobytes of random access memory. The most efficient set-up would involve a hard-disk storage system with a printer. A math coprocessor is not necessary.

3.1.1.3. Installation of the AACES-RS Software Package on Computer--To install the AACES-RS Software Package on a hard disk, do the following:

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*IBM, IBM PC, IBM XT, IBM AT, and IBM PS/2 are trademarks of the International Business Machines Corporation, Boca Raton, Florida.

Step 1. Ensure that you are in the root directory of the hard disk on which you wish to install the AACES-RS code. Create a subdirectory for the AACES-RS code on your hard disk by typing:

```
MD \AACES-RS
```

and press **Enter** (or **Return**).

Step 2. Move to the newly created subdirectory by typing:

```
CD \AACES-RS
```

and press **Enter**.

Step 3. Insert the AACES-RS Distribution Disk in the A: floppy-disk drive.

Step 4. Type:

```
COPY A:*.*
```

and press **Enter**.

For the AACES-RS software to function properly, the following commands must be in the CONFIG.SYS file in the root directory of the disk drive used to boot the system:

```
FILES=20
BUFFERS=24
DEVICE=ANSI.SYS
```

Refer to the IBM DOS reference manual for details on installing these commands.

3.2. AACES-RS USER'S MANUAL

Section 3.2 discusses the step-by-step procedure for operating the AACES-RS code.

3.2.1. AACES-RS Description

An AACES-RS run is started by simply selecting "Create New Case" from the main menu of the AACES-RS code. The user then proceeds through the run by selecting options from the main menu and submenus. The AACES-RS program displays the computed results of a run at the bottom of the screen in a box labeled "Results." It will also store the results and input parameters for each site, and cases associated with each site, in an internal database and will provide a written report for each site, if these options are selected from the main menu. The AACES-RS code will display and print out a list of the sites and of the cases for each site that are stored in the internal database. The AACES-RS code also includes a series of help screens, which are available at any time during a run, to assist the user.

The AACES-RS code first leads the user through a reference run, which is a run using default parameters for all input variables except silt content and asbestos content. The reference run becomes the first or base-line case for a site. The purpose of the reference run is to provide a common case situation from which to begin the comparison of the contamination problem at one site with the contamination problems at other sites. However, when comparing sites to determine the need for corrective action and to set priorities, a user should not necessarily accept the results from the reference case run as the final results for a site. The reference case is only a basis from which to start the comparison. A user should try to obtain the most accurate site-specific values for the input variables possible for each site being evaluated. After the reference run has been completed, the user is free to make as many different case runs for a site as is desired.

The AACES-RS code was written and compiled in Microsoft QuickBASIC* language. It uses Finally† subroutine libraries to create pop-up screens for menus and operational assistance.

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*Microsoft is a registered trademark of the Microsoft Corporation. QuickBASIC is a trade name of the Microsoft Corporation.

†Finally is a trade name for Komputerwerk.

3.2.2. AACES-RS Operation

The following is a step-by-step description of how to operate the AACES-RS code. This is a tutorial approach that will logically lead a user through a run, permitting the user to change every input variable and option associated with a code run. However, the AACES-RS code is designed to be very flexible, and it allows a user to move among the input variables and options. Therefore, once a user becomes familiar with the AACES-RS code, it will not be necessary to follow this step-by-step procedure.

The tutorial step-by-step procedure is as follows:

Step 1. Call up the subdirectory containing the AACES-RS code.

Step 2. Type in **AACES-RS** and press **Enter** or **Return**. There will be a slight pause before the first screen appears while the computer loads the AACES-RS code. The first screen asks whether you have a color monitor. Press **Y** or **Enter** if you do; press **N** if you have a monochrome monitor. Then the AACES-RS title page will appear. The statement "Press Any Key to Continue (Q for Quick Entry)" will appear at the bottom of the title page. Press any key and the AACES-RS code will continue with a series of introductory screens. If **Q** is pressed, the AACES-RS code will skip over the introductory information screens.

Step 3. The AACES-RS code will proceed to display several information screens. It will pause at each screen to allow the user to read the screen. The statement "Press Any Key to Continue" will appear at the bottom of the screen. Press any key and the AACES-RS code will continue to the next information screen. While paging through the information screens, give special attention to the screen that discusses the "capabilities and limitations" of the AACES-RS code.

When all of the information screens have appeared, you will be asked if you have a printer attached to your computer. Press Y or **Enter** if you do; press **N** if you do not. If you do not have a printer, you will be unable to use some of the AACES-RS code's options.

Step 4. Next the main menu will appear. A number of options will be listed under "Roadway Suspension," and the Help option will be highlighted. If the Help option is selected, a series of eight Help screens will appear, describing how each option works. The Help option is selected by pressing **Enter** or **Return** when the help option is highlighted. Movement between the options is done by the arrow keys, as indicated on the screen.

Step 5. Press the down arrow key twice to move the highlighted area to the "Create New Case" option and press **Enter** or **Return**. This will bypass the "Select Dase from Database" option. (The "Select Case from Database" option will be discussed in Step 15.) A set of input parameters with default values will appear on the screen, along with a pop-down menu of "Input/Modify Case", which will have the "Silt Content" option highlighted.

Step 6. Press the **Enter** or **Return** key when "Silt Content" is highlighted. This will produce a pop-down Help screen that explains the "Silt Content" input variable. The cursor will be under the "0" value listed under "Current" in the small box on the right-hand side of the screen. Enter the correct silt content value and press **Enter** or **Return**. The AACES code will then accept this entry and move the highlighted area to the "Asbestos Content" option of the pop-down "Input/Modify Case" menu.

Step 7. Press the **Enter** or **Return** key when the "Asbestos Content" option is highlighted. This will produce a pop-down Help screen that explains the "Asbestos Content" input variable. The cursor will be under the "0" value listed under "Current" in the small box on the right-hand side of the screen. Enter the correct asbestos content value and press **Enter** or **Return**. The AACES-RS code will then perform the calculations and display the input parameters and results on the screen. The results will appear in the "Results" box at the bottom of the screen. The AACES-RS code is quick, so this will appear to happen instantaneously. The same value will appear for the "Asbestos Air Concentration (structures/cc)" and the "Reference Asbestos Air Concentration (structures/cc)" in the "Results" box. This matching occurs because the first case run for a site is the reference run (i.e., the run with default parameters, except for silt content and asbestos content). Subsequent case runs for a site will show different results under "Asbestos Air Concentration", which represent the result for the case currently being evaluated. Notice that this result will differ from that listed for the "Reference Asbestos Air Concentration." The message "Press Any Key to Continue" will appear at the bottom of the screen. After reading the results screen, press the **Enter** or **Return** key to continue. The message "Enter Site Name" will then appear.

Step 8. Type in the official name of the site (up to 20 characters are allowed for the site name). The site name should be unique for each site evaluated, because the AACES-RS code assigns and tracks case runs for a site based on that site name. After typing in the site name, press **Enter** or **Return**. The AACES-RS code will then assign a case number to the run and display it on the screen. After reading it, press any key to continue, which will return the system to the Roadway Suspension subroutine menu with the "Edit/Run Current Case" option highlighted. Press **Enter** or **Return** to select this option. If only the reference case is to be run and no changes to any of the other parameters are desired, use the arrow keys to move the highlighted bar to "Print Current Case" and proceed to Step 11.

Step 9. The screen will display the parameters and results of the run just completed with the "Input/Modify Case" pop-down menu shown. The highlight bar will be on "Silt Content." The user is now free to move the highlight bar up or down through the options to select the specific input parameters to be changed. The first run was the reference run (i.e., it was run using only default parameters). Now, the user has the option of modifying any parameters desired. Parameters are changed in the same manner that the silt content parameter was changed in Step 6. Immediately after each parameter value is changed, the result is calculated and displayed. Use the arrow keys to move to each parameter that is to be changed and repeat the process. When all the desired parameter changes have been made, use the left arrow key to move to the "Previous Menu" option and press **Enter** or **Return** to bring back up the main "Roadway Suspension" menu. The menu will have the "Save Current Case" option highlighted.

Step 10. Press **Enter** or **Return** with the "Save Current Case" option highlighted. This will result in a screen displaying the statement "Enter Site Name" with the name of the site displayed after it. If this is the correct site name, press **Enter** or **Return.** The AACES-RS code will then automatically record the run under that name with the next available successive case number, and will display the site name and case number on the screen. To continue, press any key.

Step 11. The main "Roadway Suspension" submenu is now displayed with the "Print Current Case" option highlighted. If a printer is hooked up to the computer system and a printed report of the run is desirable, press **Enter** or **Return**. The AACES-RS code will then display the site name and case number being printed and print out the report for the run. After the report is printed, the AACES-RS code will return to the main "Roadway Suspension" menu with the "Display List of Cases" option highlighted.

Step 12. If you wish to see a list of the sites/cases available in the database, press **Enter** or **Return**. The AACES-RS code will then display the list of sites/cases on the screen, with the "Return to Main Menu" option highlighted. After viewing the list of sites/cases, press **Enter** or **Return**.

Step 13. The main "Roadway Suspension" menu is displayed with the "Print List of Cases" option highlighted. If a printer is hooked up to the computer system and you wish to have a printed list of the sites/cases in the database, press **Enter** or **Return**. Once the list of sites/cases is printed out, the AACES-RS code will return to the main "Roadway Suspension" menu, and the Help option will be highlighted.

Step 14. This completes the operation of the Roadway Module. The user may choose either to evaluate another site, by starting the process over again, or to quit. To quit, use the arrow keys to move the highlight bar to "Quit". The "Quit" option will halt the run of the AACES-RS code and return the system to the DOS prompt. Before doing so, if the last case run was not saved, the AACES-RS code will provide an opportunity to save it.

Step 15. If the "Select Case from Database" option mentioned in Step 5 is desired, use the arrow keys to make sure the highlight bar is on "Select Case from Database" and press **Enter** or **Return**. This will bring up a list of the sites/cases in the database. Use the arrow keys to move the highlight bar to the desired site/case and press **Enter** or **Return**. The "Edit/Run Current Case" option will be highlighted. Press **Enter** or **Return** and the AACES-RS code will display the parameters and results for the chosen site/case and display the "Input/Modify Case" option. Repeat the steps starting with Step 9 to make any modification to the case run chosen and save it as an additional case run for that site.

APPENDIX A

SAMPLING AND ANALYSIS PROTOCOLS

Although the AACES-RS code provides default values for most parameters used in the calculation of asbestos air concentrations, two user inputs are required in all cases: 1) silt content of the roadway, and 2) asbestos content of the silt fraction. The following guidelines are suggested for obtaining these measurements.

A.1. SAMPLING AND ANALYSIS FOR SILT CONTENT

Representative samples of the surface material (ca. upper 0.5 in.) from the roadway should be collected and properly stored to avoid contamination and/or mechanical disruption. The silt fraction should be determined using the sieving technique reported in ASTM C136-84a, Standard Methods for Sieve Analysis of Fine and Coarse Aggregates (ASTM, 1984). The silt fraction is defined as the weight percent of the original dry sample material that passes through a No. 200 mesh screen (85 μm).

A.2. SAMPLING AND ANALYSIS FOR ASBESTOS CONTENT

The silt fraction described above should be homogenized and representative subsamples taken for asbestos analysis. There is currently no generally accepted methodology for the analysis of asbestos in soils. Polarized light microscopy (PLM) is an interim method for the analysis of asbestos in bulk insulation samples (EPA, 1982). This method can be adapted for analyzing soils. However, because of the mass conversion problems associated with its use in the AACES codes and problems with PLM in general regarding the structures and sizes it reports, additional research is being conducted to establish an accepted protocol for the sampling and analysis of asbestos in soils. A potentially more accurate method of determining asbestos content (with results reported as number of structures per unit mass) is Transmission Electron Microscopy (TEM). The TEM method offers several advantages over ordinary light-microscope techniques, including the ability to analyze the smaller (<5-μm) asbestos size fractions. Limitations to the use of TEM include its high cost (ca. $200-600 per sample; EPA, 1985) and its poor precision and accuracy for analyzing the smallest (<1-μm) fiber sizes (Steel and Small, 1985). There is as yet no standardized protocol for the analysis of soils by TEM. Suggested references for TEM analysis protocols include Yamate et al. (1984); 40 CFR Part 763, Subpart F, App. A; and NIOSH Method 7402.

REFERENCES FOR APPENDIX A

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Steel, E.B.; Small, J.A. (1985) Accuracy of transmission electron microscopy for the analysis of asbestos in ambient environments. Anal. Chem. 57:209-213.

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APPENDIX B

MISCELLANEOUS TECHNICAL ISSUES

This guidance manual covers the development and application of the AACES-RS computer code and is not intended to be a source of general information on asbestos. Information on a variety of asbestos-related topics, including the risk to public health, is available from a number of sources, and readers are urged to consult the technical literature for this material. However, for the convenience of the reader, a brief discussion of several important asbestos-related issues has been provided below.

B.1. CURRENT EXPOSURE STANDARDS

- The Occupational Safety and Health Administration (OSHA) has established a permissible airborne exposure limit for workers of 0.2 f/cc based on an 8-h time-weighted average (TWA) (29 CFR Part 1910.1001). OSHA's current action level for asbestos in the workplace is 0.1 f/cc (8-h TWA). These standards apply to asbestos fibers with a minimum length of at least 5 μm and an aspect ratio equal to or greater than 3:1.
- The current National Institute for Occupational Safety and Health (NIOSH) standard for chrysotile asbestos is 0.1 f/cc, based on an 8-h TWA. This standard also applies to fibers with an aspect ratio of ≥3:1. Both the OSHA and NIOSH standards are based on analysis by phase-contrast microscopy (PCM).
- The National Emission Standards for Hazardous Air Pollutants (NESHAP) regulate waste materials containing asbestos (40 CFR Parts 61.140-61.156). These standards apply to the handling of asbestos and emissions from waste-disposal operations. NESHAP prohibits the use of

tailings or asbestos-laden waste material as surfacing agents for roadways (except for temporary roadways or in areas with asbestos ore deposits), but it does not currently regulate commercial asbestos-bearing stone or gravel obtained from quarry operations.

B.2. RELATIONSHIP BETWEEN FIBER SIZE AND HAZARD POTENTIAL

The link between asbestos and a number of health disorders, including asbestosis and mesothelioma, has been well established (EPA, 1986). Although the disease-causing potential of asbestos is now widely accepted, a number of issues have generated considerable discussion in the health assessment and regulatory areas. For instance, the mechanism for carcinogenesis is largely unknown, and there is disagreement on the selection and use of risk and exposure assessment models. One area in particular that has generated controversy is the use of occupational health-effects data in risk assessments for non-occupational exposures (Levadie, 1984). Furthermore, there is considerable debate among experts regarding the relationship between health effects and asbestos fiber-size. Most investigators agree that asbestos toxicity is related to fiber length, diameter, and aspect ratio, but there is still a great deal of uncertainty about the potential health effects of short (<5-μm) fibers. While it is generally acknowledged that long, thin fibers are potentially the most toxic, experts caution that short fibers should not be ignored in health assessments. Part of the problem is that the current regulatory standards for asbestos size are based on methodological definitions, rather than on known health-effects relationships.

REFERENCES FOR APPENDIX B

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APPENDIX C

VALUES OF PARAMETERS FOR THE AACES-RS CODE

Appendix C contains data necessary for running the AACES-RS code.

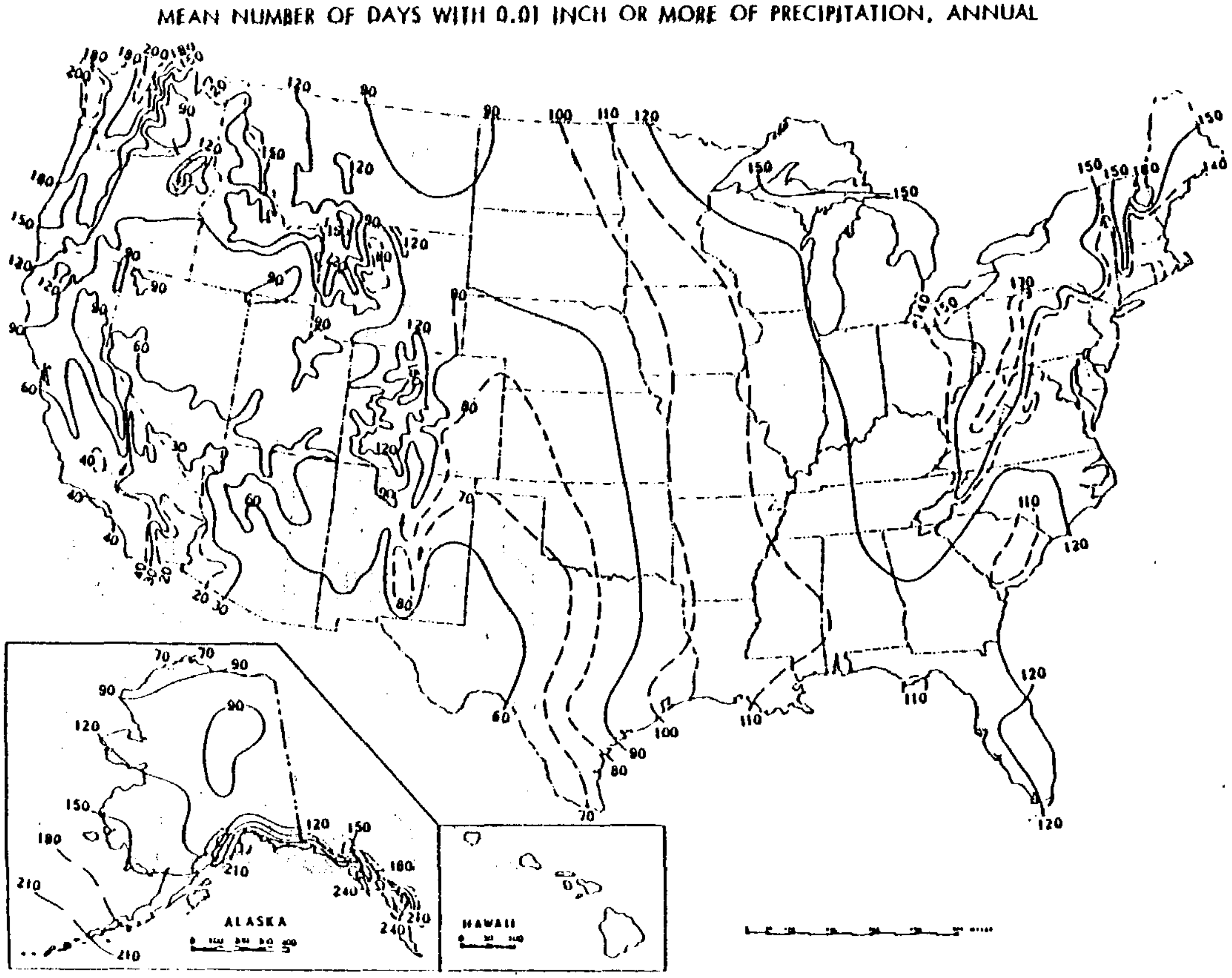

Figure C-1. Map of precipitation frequencies (number of days).

Appendix G

Air Resources Board
Model for Estimating Asbestos Concentrations From Unpaved Roads

CONTRACT NO. A032-147
FINAL REPORT
AUGUST 1992

Development of a Technique to Estimate Ambient Asbestos Downwind from Serpentine Covered Roadways

CALIFORNIA ENVIRONMENTAL PROTECTION AGENCY

AIR RESOURCES BOARD
Research Division

DEVELOPMENT OF A TECHNIQUE TO ESTIMATE AMBIENT ASBESTOS DOWNWIND FROM SERPENTINE COVERED ROADWAYS

Final Report
Contract No. A032-147

Prepared for:

California Air Resources Board
Research Division
2020 L Street
Sacramento, CA 95814

Submitted by:

Valley Research Corporation
15904 Strathern Street, Suite 26
Van Nuys, CA 91406

Prepared by:

Yuji Horie
Steven Sidawi
Craig Tranby

AUGUST 1992

DISCLAIMER

ABSTRACT

In the foothills of the Sierra Nevada Mountains, serpentine rock has been mined extensively and widely used as a material for many types of unpaved surfaces, including parking lots, driveways, roads, and apparently even some school playgrounds. When vehicles are driven over unpaved roads surfaced with asbestos-containing serpentine material, asbestos fibers are released into the atmosphere as part of the resultant dust cloud. Thus persons near the roadway, especially on the downwind side, are exposed to elevated ambient concentration of asbestos. The goal of the present study was to quantify asbestos concentrations downwind of these roadways and relate the concentrations to vehicle traffic, road surface materials, and meteorological and climatological conditions.

After reviewing the occurrence of serpentine-covered unpaved roads in various parts of California and visiting roads throughout the State, it was found that the locale most suitable for study was in the vicinity of Oakdale in eastern Stanislaus County. After gaining permission from landowners, four sites were selected for field experiments. At each site, a network of four to five asbestos monitoring stations was established as well as a meteorological station for measuring wind speed and direction. During 5 to 8 one-hour test runs at each site, traffic was simulated on the road by repeated van trips while air samples were taken and meteorological conditions were monitored. Bulk samples of the road surface material were also taken for analysis of bulk asbestos content, silt content, and moisture content. Air samples were analyzed for asbestos using both optical and electron microscopes for two size ranges: all structures and structures ≥ 5 μm.

The EPA model that consists of the Copeland road dust emission model and Gaussian line source equation was evaluated by comparing measured asbestos concentrations with concentrations predicted by the model for the test conditions. The EPA model was found to be good only to estimate an order of magnitude of downwind concentrations. The structure of the model was found to be generally adequate, but the inclusion of both short temporal and long-term average parameters in the model appeared to decrease the accuracy of model estimates. Residual analysis of model-predicted concentrations less measured concentrations revealed that the model tends to overestimate asbestos concentrations at lower vehicle speeds and the model's performance is skewed with respect to model's site parameters such as moisture, silt, and asbestos contents.

A modified roadside asbestos model called CALSCRAM was developed by rectifying some of the defects found in the EPA model. The new model, which was calibrated over the range of 14% to 18% bulk asbestos content, was found to reduce the EPA model prediction errors by 76%. It is capable of predicting both short-term and long-term average asbestos concentrations and has a feature that accounts for the effect of a finite road segment on downwind concentrations.

ACKNOWLEDGMENTS

This roadway asbestos study could not have been completed without help from numerous individuals. Dr. Susanne Hering of Aerosol Dynamics, Inc., provided expert advice and assistance in designing the field experiments. Arthur Shrope of VRC and Dr. Wayne Harrington of ATC Environmental, Inc., contributed additional ideas and planning assistance early on in the project. For assistance during our site identification and selection effort we thank Tim Moore of the BLM in San Benito County, Scott Adams of the BLM in Lake County, the APCDs and Public Works Departments of northern and central California, the U.S. Forest Service staff in Stanislaus, El Dorado, and Shasta National Forests, and several cooperative private landowners. Arvid Severson of Severson Company, Inc., provided assistance with instrumentation. Larry Bregman and Dr. Charles Pyke of Continental Weather Service provided invaluable climatological assessments and weather forecasts for the field sites.

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ABBREVIATIONS AND ACRONYMS

AACES-RS	Airborne Asbestos Concentration Estimator System-Roadway Screening, a computer code for the EPA model which was developed by Battelle Northwest Lab.
APCD	Air Pollution Control District
ARB	Air Resources Board
ATC	ATC Environmental Inc., subcontractor for asbestos sampling and analysis
ASTM	American Standards for Testing and Materials
CALSCRAM	California Serpentine-Covered Roadway Asbestos Model, the model developed under the present study
EDS	Energy Dispersive Spectroscopy
EPA	Environmental Protection Agency
ft	Feet
g	Gram
km/h	Kilometers per hour
m	Meter
mph	Miles per hour
m/s	Meters per second
NIOSH	National Institute for Occupational Safety and Health
NWS	National Weather Service
OSHA	Occupational Safety and Health Administration
PCM	Phase Contrast Microscopy
PLM	Polarized Light Microscopy
SAED	Selected Area Electron Diffraction
struc/cc	Structures per cubic centimeter
struc/g	Structures per gram
TEM	Transmission Electron Microscopy
TEM0	TEM-measured asbestos concentration for all structures having ≥ 3 to 1 aspect ratio regardless of size
TEM5	TEM-measured asbestos concentration for structures ≥5 μm and having ≥ 3 to 1 aspect ratio
μg	Microgram (10^{-6} gram)
vph	Vehicles per hour
VRC	Valley Research Corporation

1.0 INTRODUCTION

1.1 BACKGROUND AND OBJECTIVES

Serpentine rock is widespread in California. In the foothills of the Sierra Nevada mountains, serpentine rock has been mined extensively and has also been widely used as a material for many types of unpaved surfaces, including parking lots, driveways, roads, and apparently even some school playgrounds. It has an attractive blue-gray or greenish appearance, and it can be locally inexpensive and readily available. These factors, along with its superior compaction properties contribute to its frequent use in certain areas of the Sierra foothills.

Serpentine rock in many parts of California can also have a significant content of the chrysotile form of asbestos. Since 1986, when the California Air Resources Board (ARB) first identified asbestos as a toxic air contaminant, a number of bulk samples of serpentine material have been taken in California and analyzed for asbestos content. ARB has identified serpentine deposits with asbestos contents ranging from trace amounts to as high as 90 percent, with typical contents in the Sierra Nevada falling between 2 and 20 percent. Asbestos is a known human and animal carcinogen, and exposure to asbestos has been linked to a number of serious illnesses including lung cancer, mesothelioma, and asbestosis.

When vehicles are driven over unpaved roads surfaced with asbestos-containing serpentine material, asbestos fibers are released into the atmosphere as part of the resultant dust cloud. Thus persons near the roadway, especially on the downwind side, are exposed to elevated ambient concentration of asbestos. In response to these health concerns, many serpentine-covered roads in California have already been paved over, and regulations have been enacted to prevent further road surfacing with serpentine material having more than a 5% asbestos content. However, according to ARB (1990), there are still hundreds of miles of serpentine-covered roads in the State, and some of these roads are near residences or human activity.

1.1.1 BRIEF SUMMARY OF PREVIOUS RESEARCH

A number of studies conducted over the past 15 years along serpentine-covered roads have revealed high ambient levels of asbestos fibers generated by the mechanical action of vehicle traffic. The most ambitious of these was a 1987 study done by Ecology and Environment, Inc., for the U.S. Environmental Protection Agency (EPA), in which airborne asbestos concentrations downwind from a single roadway in Amador County were related to the asbestos content of the road surface material and simulated vehicle traffic on the roadway (EPA 1987, 1988). Several other investigations have looked at asbestos emissions from unpaved roads or off-road vehicle trails over native serpentine soil.

In the above EPA project, two different serpentine-covered roadways were originally selected for study, both on private property in the foothills east of Stockton and Sacramento. EPA personnel reached agreement with property owners at these two sites, and scheduled field work at both. However, work at one site was ultimately scrubbed due to unfavorable topography and wind conditions. Therefore, one road only, in western Amador County, was subjected to field experiments (EPA 1988).

To determine the effects of vehicle traffic on downwind concentrations of airborne asbestos, the EPA-sponsored study team erected meteorological monitoring and air sampling equipment downwind of the subject roadway (a single air sampling station was also placed upwind to determine background concentrations). The most distant downwind station was located at 100 ft. from the roadway. Experiments consisted of a series of one hour sampling runs, and some 8 hour sampling runs, during which a van was driven over a 100 ft. study section of the roadway at intervals of 15 minutes at a constant speed of 30 mph. No variations in these traffic conditions were attempted. Several bulk samples of the road surface material were also taken for analysis of asbestos content, silt content, and road moisture content. All bulk and air samples were forwarded to independent laboratories for phase contrast microscopy (PCM) or transmission electron microscopy (TEM) analysis. Laboratory results were entered into databases in conjunction with traffic and meteorological data specific to each sampling run.

As part of this EPA-sponsored work, a computer code was developed by Battelle Memorial Institute's Pacific Northwest Laboratory (Stenner et al. 1990). The code, named AACES-RS, uses a modified form of the Copeland Model (EPA 1985) to estimate downwind concentrations from a contaminated roadway. Among the improvements to the standard Copeland model found in the AACES-RS are the ability to analyze variable downwind distances instead of a fixed "within 50 feet" and consideration of wind speed and stability variables as model inputs. The primary input variables for the AACES-RS code are site specific silt content and asbestos content. For other input variables, AACES-RS contains default values but allows user input of the following variables:

1. Particle-Size Multiplier (k-factor)
2. Vehicle Speed
3. Vehicle Weight
4. Number of Wheels
5. Vehicle Frequency (number of vehicles per hour)
6. Vertical Dispersion Parameter (σ_z)
7. Distance from Road
8. Precipitation Days (number of days per year with precipitation)
9. Stability Class
10. Average Wind Speed
11. Initial Vertical Dispersion of Vehicle Wake (H)

The AACES-RS code (hereafter referred to as the "EPA model") was calibrated using the results of the EPA field work in Amador County. However, owing to the limited amount of field data and the narrow range of experimental conditions investigated, little improvement to the modified version of the Copeland Model was possible. Thus the model is believed to be accurate to an order of magnitude at best. Prior to the current study, the model has never been adequately validated or field tested.

1.1.2 OBJECTIVES

In California, there are at least hundreds of miles of existing roads that either traverse native serpentine soils or are surfaced with hauled-in serpentine material. Many of the health-related issues regarding these roads are still a subject of debate. However, a need has been recognized to evaluate existing roads and prioritize them as to their potential for contributing to public exposure to airborne asbestos. Since it would be prohibitively difficult to conduct individual field tests on all existing serpentine-covered roadways, a better approach would be to develop a predictive model which takes a few site specific parameters as model input and yields, as output, the ambient asbestos concentration as a function of distance from the roadway. Such a model can provide a cost effective way of evaluating a large number of roadways. The EPA has developed a model for such a purpose, but it has not been validated or field tested.

The primary objectives of this study, therefore, were to conduct field experiments at multiple sites in California under a wider range of conditions than had previously been investigated, and to use these results to validate and improve the existing EPA model or to replace it with an improved model.

1.2 SUMMARY AND CONCLUSIONS

After an extensive search for roadways suitable for study, several candidate serpentine-covered roadways were identified in the Sierra Nevada foothills. All were on private property. Permission to use them for study was sought and granted by most property owners. Field work was conducted during August and September, 1991, by Valley Research Corporation (VRC) and its subcontractor ATC Environmental, Inc.

Field work was completed at four sites, all of which were in the general vicinity of Oakdale in Stanislaus County. At each site, a 500 ft. section of the road was chosen for study. One air sampling station was set up upwind of the roadway and 3 to 4 stations were set up downwind. Two meteorological stations were also established, one to measure wind speed and direction; and the other to measure temperature and relative humidity. Several bulk samples of the road surface material were taken at each site, for analysis of silt content, asbestos content (by ARB Test Method 435), and moisture content. To make the study results usable for dispersion modeling, atmospheric stability variables were also recorded.

Field testing consisted of about six 1-hour experimental runs at each site. During the runs, traffic was simulated on the roadway by driving a van back and forth across the study section at designated speeds and time intervals. In total, four vehicle frequency conditions -- 5 vehicles per hour, 15 vehicles per hour, 45 vehicles per hour, and no traffic -- and two vehicle speeds -- 10 mph and 25 mph -- were investigated.

Air and road surface samples collected in the field were subjected to laboratory analyses. For bulk samples, these analyses were to determine asbestos content, silt content, and moisture content; for air samples, asbestos content by TEM and PCM analyses.

Results of the field experiments were compared to ambient asbestos concentrations predicted for the field conditions by the EPA model. Based on discrepancies between measured and model-predicted concentrations, a modified model, named CALSCRAM (California Serpentine-Covered Roadway Asbestos Model), was developed.

This study has yielded the following findings and conclusions:

- Although serpentine-covered unpaved roads indeed exist in many parts of California, nearly all unpaved roads covered with serpentine material on public land are either unsurfaced roads or off-road vehicle trails over native serpentine soil, or logging roads in mountainous, forested and often remote areas.

- Serpentine-covered unpaved roads in the vicinity of residences and centers of human activity suitable for field tests are common only in the Sierra Nevada foothills of California from approximately Mariposa County in the south to Placer County in the north.

- Traffic over serpentine-covered unpaved roads was found to generate measurably elevated levels of airborne asbestos at downwind distances to at least 250 feet.

- The EPA model for estimating airborne asbestos concentrations downwind of serpentine-covered roadways was found to predict concentrations accurately to an order of magnitude, but it performed poorly for low vehicle speeds and certain ranges of other input parameters.

- A modified model, called CALSCRAM, was developed based on the field data collected under the present study. This model not only out-performs the EPA model for estimating downwind asbestos concentrations but also possesses capabilities of predicting both short-term and long-term average concentrations. The model can also account for the effect of shorter road segments on downwind concentrations.

The model developed under this study provides a cost-effective tool for determining whether identified serpentine-covered unpaved roads pose risks of public exposure to elevated ambient levels of asbestos.

Although the model is capable of predicting asbestos concentrations downwind of unpaved roads surfaced with imported mined serpentine rock, it has not been tested on unsurfaced roads with native serpentine material. Therefore, recommendations for future research in the subject area are as follows:

(1) Design and implement a similar experiment to evaluate the model's applicability to unpaved roadways consisting of native serpentine material. These roadways appear to be far more prevalent in California than roadways surfaced with imported serpentine material.

(2) Develop a comprehensive compilation of unpaved roads in California covered by mined serpentine and native serpentine and determine their spatial distribution and vehicle activity levels.

(3) Identify regions in California where these roads occur in conjunction with human activity. Employ the model on roads in these regions to make first-order estimates of public exposure levels and develop priorities for further efforts on assessing health risks from such exposure.

2.0 EXPERIMENTAL METHODS

2.1 SELECTION OF STUDY SITES

Prior to this study, ARB staff estimated that in California there are at least 700 miles and possibly thousands of miles of publicly-owned serpentine-covered unpaved roads and possibly hundreds more miles that are privately-owned (ARB 1990). These estimates were based on conversations with several Air Pollution Control Districts (APCDs) in California counties with unpaved roads. However, no systematic compilation of either exact road mileage or road locations has yet been attempted. Thus there was no existing database to aid in the process of site selection for this study.

To aid in the identification of potential sites, we contacted knowledgeable officials at local APCDs, county public works departments, national forests and national parks, Bureau of Land Management, Caltrans, EPA, and ARB. Based on these conversations, we identified specific regions in California with potential study roads. A site reconnaissance tour of these regions was conducted for the purpose of identifying candidate sites and recording preliminary information on road characteristics, site topography, and meteorology, as well as for taking road surface samples for asbestos analysis.

Based on the results of the reconnaissance tour, it was concluded that although serpentine-covered unpaved roads indeed exist in many parts of California, the overwhelming majority do not meet basic experimental requirements, such as having a straight road segment, level terrain, and an absence of major obstructions such as trees or buildings. Moreover, nearly all unpaved roads covered with serpentine material on public land are either unsurfaced roads or offroad vehicle trails over native serpentine soil, or logging roads in mountainous, forested and often remote areas. These roads were not suited for the experimental approach.

Each candidate site was subjected to independent review first by meteorologists of Continental Weather Service and then by ARB staff. Based on this review, the pool of suitable candidate sites was reduced to several sites located in the vicinity of Oakdale in eastern Stanislaus County. The Oakdale region is distinct from other parts of the Sierra Nevada foothills in that most serpentine-covered roads are on open and level terrain. Outside of the Sierra Nevada, we were unable to locate <u>any</u> serpentine-covered roads other than unpaved roads over native serpentine material or roads with an unacceptably low serpentine content. One unpaved road over native serpentine material (in Lake County) was originally included in this study and subjected to preliminary field work, but results were ultimately excluded from the study by the ARB contract manager based on its native serpentine content and roadside slope.

The region north to northeast of Oakdale is characterized by flat and gently sloping open rangeland. Houses in this region are typically set far back in ranch-type parcels and connected to the paved public roads by straight driveways several hundred feet in length. A majority of these driveways are unpaved, and many of the unpaved driveways are surfaced with serpentine material. We identified an initial pool of about 10 straight, flat, serpentine road segments, which were primarily driveways. The property owners at each road segment were identified and contacted, and based on their receptiveness to our initial inquiries about use of their roads for the study, we reduced the number of candidate sites to 7. One liter bulk samples of the road surface material were taken and analyzed for asbestos content according to ARB Test Method 435, and each of the sites was found to have a chrysotile asbestos content within the range of 5 to 20 percent. Selection of final study sites was left until within a few days of each study period in order to incorporate the latest wind forecasts for selecting the road segments with optimal orientations.

The four study roads that were finally selected each had the distinctive "green" appearance of roadways covered with hauled-in serpentine, and each functioned as a driveway used for access between a public road and a private ranch. Three of the four had residences near or at the terminus of the roadway. All were on relatively flat and open rangeland, and three of the four had cattle or horses grazing in adjacent fields. Following is a more exact description of each study site:

Site 1:
VRC Code: P5
Road Orientation: 165° (from magnetic north)
Roadside Terrain: Flat and open pasture, short grass.
Roadside Obstructions: Some small trees along the downwind roadside, barbed wire fences on either side.

Site 2:
VRC Code: 7-3
Road Orientation: 167°
Roadside Terrain: Flat and open pasture, short grass.
Roadside Obstructions: Barbed wire fence on west side.

Site 3:
VRC Code: P8
Road Orientation: 168°
Roadside Terrain: Flat and open pasture, somewhat marshy, vegetation about 2 to 3 ft. high.
Roadside Obstructions: None

Site 4:
VRC Code: P9
Road Orientation: 73°
Roadside Terrain: Flat and open pasture, short grass.
Roadside Obstructions: Barbed wire-like fence to the south, chain-link fence to the north.

Figure 2-1 shows a map of the Oakdale region and the approximate locations of the four study sites.

2.2 EXECUTION OF FIELD EXPERIMENTS

The field experiments were conducted over 9 days during the months of August and September, 1991. Study personnel consisted of two VRC staff members and one ATC asbestos sampling technician. Each study day consisted of 2 to 4 one hour test runs during which samples of airborne asbestos were taken. The test runs were generally begun during a time when the wind was approximately perpendicular to the road segment under study. On most study days, such winds occurred during the afternoon hours.

2.2.1 PROTOCOL DEVELOPMENT AND STUDY DAY SELECTION

A detailed study protocol was developed specifying the methodologies to be employed in taking bulk samples, air samples, meteorological data, and in simulating traffic. A matrix specifying the traffic conditions designated for each experimental run was developed. Comprehensive equipment checklists were also prepared and thoroughly reviewed. Data sheets were prepared to be used by the field team to monitor the progress of the field tests.

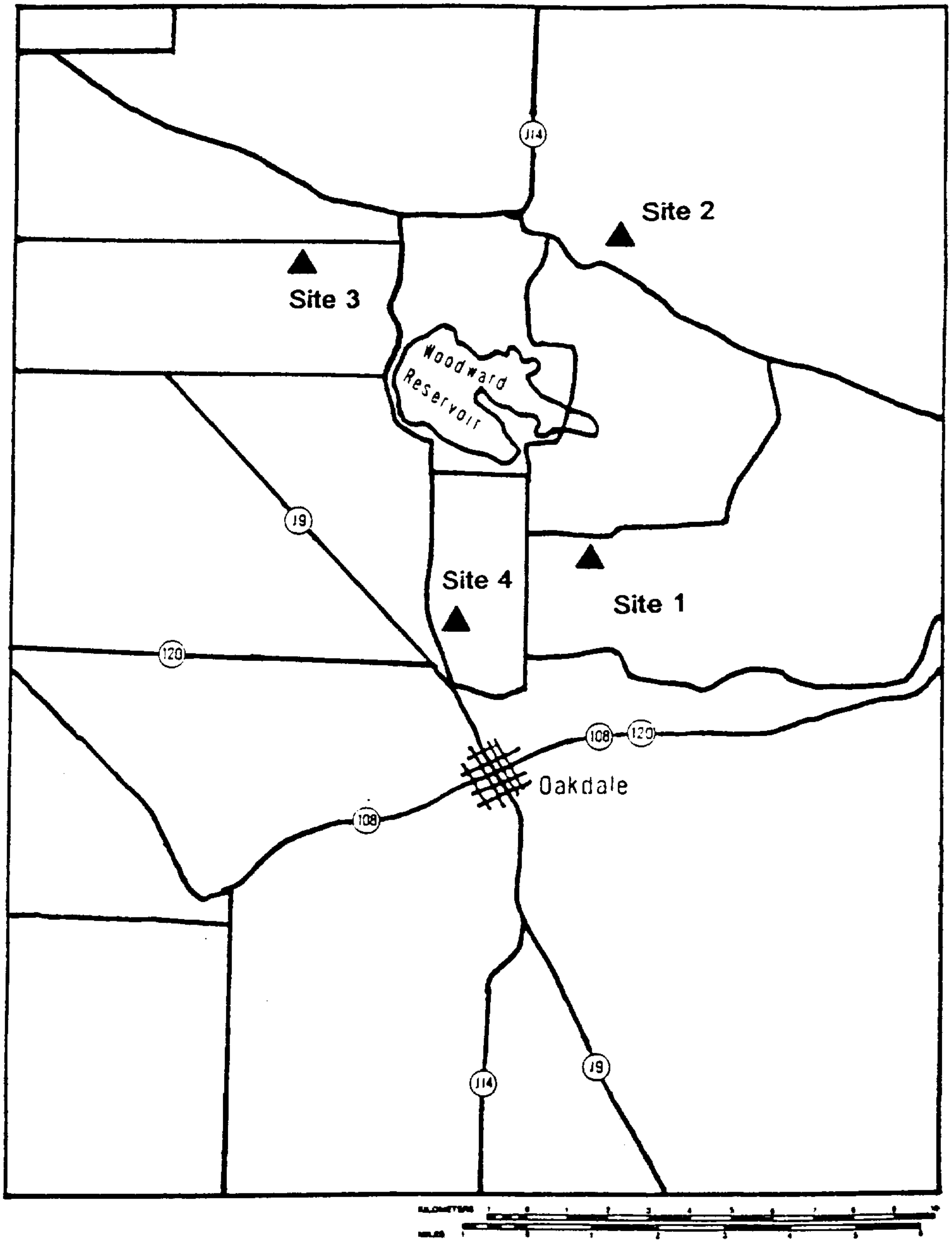

Figure 2-1. Map of the Oakdale Region Showing Locations of the Four Study Sites.

VRC made arrangements with meteorologists at Continental Weather Service to monitor weather conditions in the Oakdale region and provide detailed daily 4 day forecasts on wind speed and direction and rain probability beginning 3 to 4 days prior to any planned mobilization of the field team. Also, before visiting the first site studied, a VRC field assistant was dispatched to Oakdale 2 days in advance of the scheduled experiments to monitor winds with a handheld anemometer and verify the forecasts. Use of forecasts combined with advance site visits proved quite useful for selecting road segments with optimal orientations, and in one case for averting the mobilization of the entire field crew when rain was forecasted and confirmed prior to a scheduled field visit.

2.2.2 FIELD EXPERIMENT SETUP

Figure 2-2 depicts the arrangement of air sampling and meteorological monitoring stations in relation to the test road segment. The test segment has a 250 ft constant speed zone in each direction from the midpoint.

Each road segment's midpoint was chosen at a point relatively free of downwind obstruction with good roadside access, and where there was an adequate road length on either side. The study zone on the road segment, including the segment's midpoint and constant speed zone, was marked using a combination of traffic cones and stake wire flags.

The bearing of the test segment of the road was first measured with a compass, and all air samplers, at 4 to 5 air sampling stations, were then set up along a line perpendicular to the road segment's orientation. The first station was located at 50 ft. upwind from the road. The remaining stations were established downwind from the road at 25 ft., 75 ft., and 250 ft. A fifth station, termed the "distant sampler", was established at 1100 ft. at one site only. At the 25 ft. downwind station, samplers were mounted at heights of 1.5 m and 3 m, while at all other stations samplers were mounted at 1.5 m only. A floating replicate sampler was randomly placed at one of the stations prior to each test run.

At each site, a wind monitoring station was established 25 ft. upwind from the roadway so not to be affected by passing vehicles. A temperature and relative humidity station was established at the immediate roadside to measure conditions just above the road surface. The command station provided a central location for traffic and meteorological monitoring by the VRC field manager as well as for maintaining refreshments and miscellaneous research supplies.

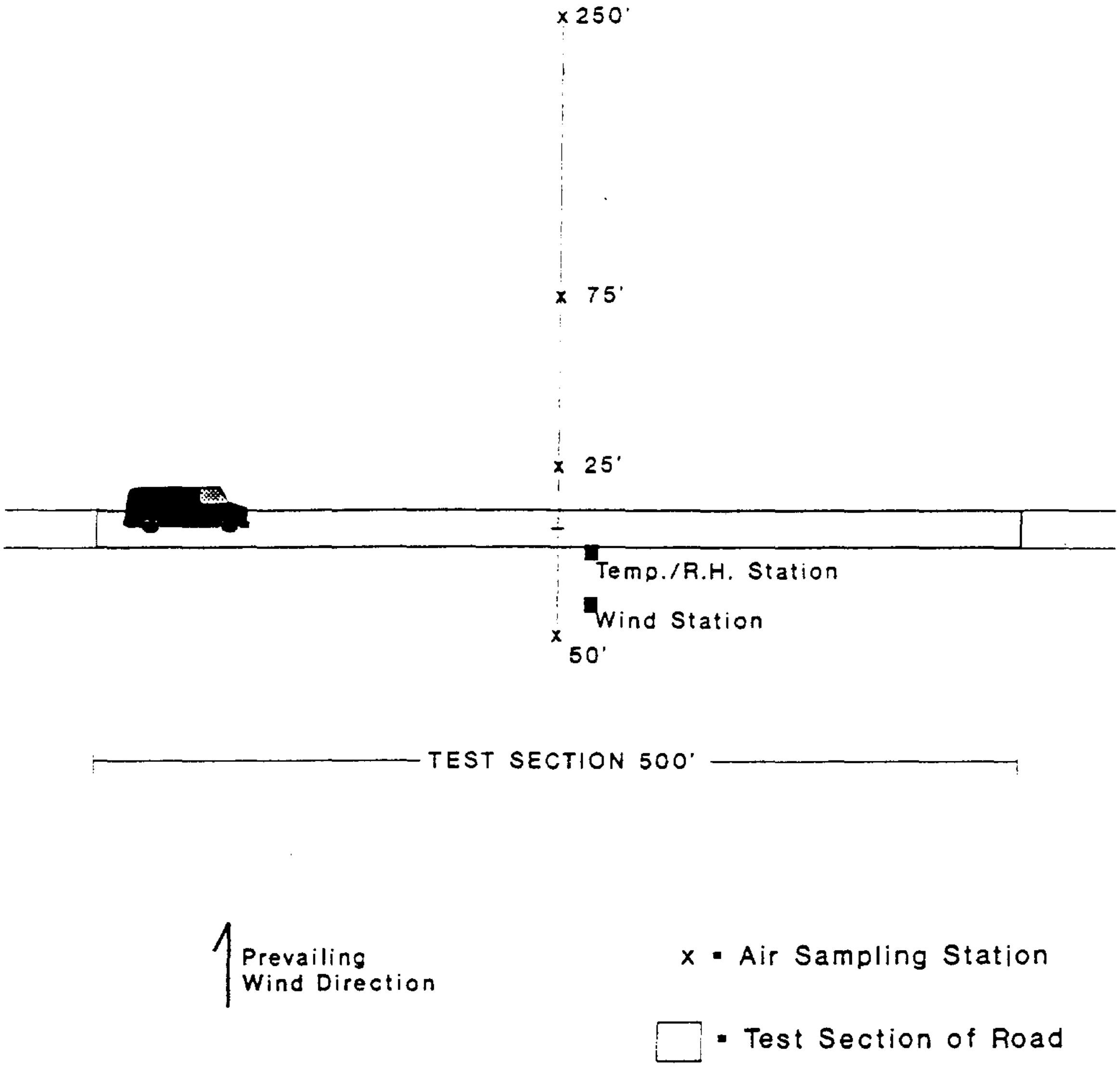

Figure 2-2. Setup Diagram for Study Sites.

2.2.3 TRAFFIC SIMULATION

For the purposes of eventual model development, the field tests were designed to focus on repeating similar traffic conditions rather than testing a multitude of traffic conditions without repeats. After considering issues such as expected dust generation per vehicle pass, real-world traffic conditions, and safety, traffic conditions were designated for 27 test runs as shown in Table 2-1. It was also decided that rather than trying to vary the vehicle type and weight, only one vehicle of "typical" size and weight would be used.

Table 2-1. DESIGNATED TRAFFIC CONDITIONS

Vehicle Speed (mph)	Vehicle Freq. (vph)	Number of Test Runs				
		Site 1	Site 2	Site 3	Site 4	Total
0	0	1	1	1	1	4
10	5	0	1	1	1	3
10	15	2	1	1	0	4
10	45	2	1	2	0	5
25	5	1	1	1	1	4
25	15	1	1	1	1	4
25	45	1	1	0	1	3

The vehicle speeds designated, 10 and 25 mph, are lower than the assumed average vehicle speed of 30 mph in the EPA study. The AACES-RS code uses a default value of 30 mph based on a survey of drivers on unpaved roads in the St. Louis area by Cowherd and Guenther (1976). Serpentine covered roads in California, however, are typically found as winding roads in the foothills or as rural driveways, where vehicle speeds are likely to be slower, for reasons of safety (in the case of winding roads) and to minimize dust generation (especially when near residences). Although typical vehicle frequencies on these serpentine-covered roads are likely to be less than 1 or 2 vehicles per hour, higher frequencies of 5, 15 and 45 vehicles per hour were employed for this study in order to ensure that the traffic would generate a measurable range of airborne asbestos concentrations.

At each study site, the first test run was conducted to determine the "background" asbestos level, namely, concentrations present prior to the experiment. This involved completion of a one hour sampling period with no traffic on the road segment. On subsequent runs, traffic was "simulated" by a single unloaded cargo van (Ford Econoline 150, unladen weight 1.8 tons) driven by a VRC staff member. The van was driven over the study segment at constant speed and at regular intervals both specified in advance. The driver and field manager maintained constant audio contact via two-way radios. Each time the study vehicle passed the midpoint of the road segment, the field manager noted on the traffic data sheet the exact time, vehicle direction, and vehicle type.

Occasionally, during the course of the experiments, access to the road was requested by non-study vehicles which were stopped and informed of the study and asked either to drive through at 2 mph (to minimize disturbance) or to pass at the designated time and speed as a substitute for the study van. The vehicle type (e.g., auto, pickup, van), speed, direction, and the time were noted for all non-study vehicles.

2.2.4 METEOROLOGICAL MONITORING

Wind speed and direction were measured continuously during each entire study day with a Young wind sensor Model 05103 (combination vane and anemometer) mounted on a 10' tripod. The following data items were automatically recorded in a Campbell Scientific, Inc., datalogger once each minute: time, mean absolute wind speed, vector wind speed, mean wind direction, and standard deviation of the wind direction. At the end of each study day, all data were downloaded to a laptop computer for quality checks and backup to hard and floppy disks.

Temperature and relative humidity readings were recorded manually each 30 minutes from an Oakton hygrometer/thermometer placed in a well-ventilated shaded area approximately 6 feet above ground level at the edge of the study road. Percent cloud cover was also recorded for each experimental run and solar angle was calculated based on the time of the run. These cloud cover and solar angle data in conjunction with wind data were later used to determine the atmospheric stability class for each test run.

2.2.5 BULK SAMPLING

In addition to the previously noted screening samples, at each site three "composite" bulk samples of the road surface material were taken and analyzed for asbestos content according to ARB Test Method 435. Composite samples were also taken prior to each test run and analyzed for moisture and silt content.

All bulk samples were taken using a clean round-tipped shovel. Each sample was taken from approximately the top 1/2 inch of the road surface at three longitudinal distances on the road segment: at the midpoint and at points 150' from the midpoint in either direction along the roadway. Samples were sealed in sterile 1 liter containers.

2.2.6 AIR SAMPLING

As mentioned earlier, four air sampling stations were established along a line perpendicular to the roadway -- one upwind (50 ft.) and 3 downwind (25 ft., 75 ft., and 250 ft.). A fifth station, the distant sampler, was established at one site only. All but the 25 ft. downwind station consisted of a single air collection pump with a filter sampler mounted at 1.5 m. The 25 ft. station consisted of two air collection pumps with one sampler mounted at 1.5 m from the ground and another at 3 m. Additionally, one "floating" sampler was collocated to acquire a replicate sample for each of the test runs . Because no other power source was available, portable generators were used to power all air pumps.

Before each one hour test run, each sampler was loaded with a labeled mixed-cellulose ester filter cassette with a .45 micron pore size. At the signal of the field manager, the pumps were turned on at the start of the run. Flow rates for each of the samplers were measured, using "The Gilibrator" primary flow electronic calibrator (Gilian Instrument Corp.) near the beginning and end of the run. At the end of the run, power to the air pumps was turned off and the filter cassettes were collected and sealed. The distant sampler, used 2 days at a single study site, was turned on at the beginning of the study day and turned off at the end. For the "background" test runs, which occurred once per site, only 3 samplers were used: upwind 50 ft., downwind 25 ft. at 1.5 m, and downwind 75 ft.

As a routine quality assurance measure, "field blanks" and "lab blanks" were collected once per site. The purpose was to establish the integrity of the sampling cassettes in the handling process both at the site and in the laboratory.

2.3 LABORATORY METHODS

All field samples were clearly labeled, packaged, and transported according to ATC's chain-of-custody procedures. The following paragraphs briefly describe the laboratory procedures that were used for silt/moisture content analysis, bulk sample analysis, and PCM and TEM analyses of air samples.

2.3.1 SILT AND MOISTURE CONTENT ANALYSIS

Moisture content for the bulk samples was determined according to ASTM Method D2216 which is a standard test method for laboratory determination of water (moisture) content of soil and rock. The method consists of oven drying the samples at 110°C to a constant mass. Moisture content is then calculated from the difference in sample weight before and after drying.

Silt content determination was based on ASTM Method D1140 which is a standard test method for quantifying the amount of material in soils finer than a No. 200 sieve. The method consists of washing and dry-sieving samples through nested sieves (upper sieve is a No. 40 and lower sieve is a No. 200). Silt content, or percentage of material finer than a No. 200 sieve, is based on the dry weight of the sample after washing and dry-sieving divided by the original sample dry weight.

2.3.2 BULK SAMPLE ASBESTOS ANALYSIS

Bulk sample preparation was accomplished by crushing the material to a nominal size of less than 0.375 inch. The sample volume was reduced to one pint as per ASTM Method C-702-80. The one pint sample was further reduced in particle size to produce a material of which the majority passed a 200 mesh Tyler screen.

The one pint sample was first examined macroscopically for color, texture, homogeneity, and visible fibers. A portion of the sample was placed on a watchglass and its fibrous content was examined under a stereomicroscope. An aliquot of the sample was removed and spread out on a glass slide. Two drops of 1.55 refractive index solution was added to the aliquot and a coverslip was placed on top of the slide. Three slides were prepared for each sample.

The slides were then examined under polarized light microscopy where fibrous structures were analyzed noting color and pleochroism, morphology, index of refraction, extinction, sign of elongation, and dispersion staining colors. Once the fibrous content was identified, a visual percentage estimate was recorded based on macroscopic and microscopic observations.

Asbestos content was then quantified according to ARB Test Method 435.

2.3.3 AIR SAMPLE ASBESTOS ANALYSIS

All air samples were subjected to TEM and PCM analyses in ATC's laboratory in Sioux Falls, SD. TEM analysis followed the microscopic methods according to EPA's AHERA Method. A set number of 200-mesh electron microscopy grid openings were analyzed as governed by the grid opening and the analytical sensitivity. Structure counting criteria were based on being greater than 0.25 microns in length with a length-to-width ratio of 3:1 or greater. Structures meeting the counting criteria were analyzed by selected area electron diffraction (SAED) and Energy-Dispersive Spectroscopy (EDS) for asbestos identification. It should be pointed out that although most of the fibers can be identified as asbestos or non-asbestos, there are still some cases where a fiber will have borderline data and thus cannot be ruled out as non-asbestos. These "borderline" fibers were labeled ambiguous, but were included in the asbestos calculations.

A portion of each sample was analyzed by PCM according to NIOSH Method 7400. The samples were prepared by removing a pie-shaped wedged portion from each sample cassette filter. The samples were then mounted by the acetone/triacetin on individual sample slides. The microscope was set up and its optics were adjusted according to the 7400 Method. The slide was examined under the microscope where the 7400 Method counting rules were implemented. Only fibers equal to or greater than 5 micrometers in length with an aspect ratio of 3:1 or greater were counted. Slides were examined until a fiber count of 100 or a field count of 100 is yielded with a minimum of at least 20 fields examined. The fiber concentration was then calculated based on the microscope graticule field area, filter cassette field area, sample volume, fiber count, and field count. All air sampling results were examined for consistency and anomalies before and after being entered into VRC's computer system.

3.0 RESULTS OF FIELD EXPERIMENTS

3.1 ACTUAL TRAFFIC CONDITIONS AND AIR SAMPLING CONFIGURATIONS

Both the traffic conditions (i.e., vehicle speed and frequency) and the configuration for active air samplers for each test run were designated prior to execution of the field experiments. In general, the field team was able to conform to these designations. On 3 occasions, however, a predesignated test run was completed but later discarded after review of the wind conditions. Table 3-1 summarizes the number of bulk and air samples analyzed for each traffic condition. Table 3-2 shows in detail for each test run the actual traffic conditions and active air sampler configuration. A symbol indicates that TEM and PCM analyses were performed for a particular sample. Test runs containing no symbols are those that were discarded due to poor wind conditions.

3.2 AIR AND BULK ASBESTOS SAMPLES

Table 3-3 summarizes the TEM-measured asbestos concentrations (i.e., TEM0 for total structures having ≥ 3-to-1 aspect ratios regardless of size) at each study site, according to the traffic conditions for the test runs. The table shows measured ambient asbestos concentrations both upwind and downwind of each roadway. For all test runs with simulated traffic, concentrations were higher downwind (note: upwind samples are all at 50 ft). Concentrations were generally higher on test runs with higher vehicle speed and frequency. Table 3-4 presents a more detailed summary of the TEM, PCM, and bulk sample analyses results for each test run at each site. The table corresponds to the actual traffic conditions and air sampling configuration shown in Table 3-2. Note that the bulk asbestos content of the road surface material is the mean of three composite samples. Also, note that the last sample listed under each test run is a collocated sample, included to test the variability observed between two samplers at similar locations.

Of the 128 air samples analyzed by TEM, about 93% were positive for chrysotile asbestos. Amphibole and "Ambiguous" were the other designated forms of asbestos and occurred in trace amounts in 15.6% and 4.7% of the samples respectively. Non-asbestos fibers identified were grouped into Antigorite and "Other" and occurred in trace amounts in 9.4% and 18.8%

Table 3-1. SUMMARY OF TEST CONDITIONS AND
BULK AND AIR SAMPLES ANALYZED

Vehicle Speed (mph)	Vehicle Freq. (vph)	Bulk Samples		Air Samples Analyzed				
		Asbestos	Moisture & Silt[a]	Blank[b]	Back-ground[c]	Upwind	Down-wind	All Day Sample[d]
0	0	4	4	0	12	4	8	1
10	5	0	2	0	0	2	10	0
10	15	0	4	0	0	3	15	1
10	45	3	5	4	0	4	20	0
25	5	0	3	0	0	3	15	0
25	15	3	4	0	0	4	20	0
25	45	2	3	4	0	3	15	0
Total		12	25	8	12	19	95	2

[a] Some moisture and silt analyses were performed on the same sample as used for bulk asbestos content analysis.

[b] Both field and laboratory blanks.

[c] For background asbestos concentrations present prior to road tests.

[d] Two all day samples were analyzed. They were each collected on days with 3 to 4 test runs.

Table 3-2. ACTUAL TRAFFIC CONDITIONS AND AIR SAMPLING CONFIGURATION FOR EACH TEST RUN

Site No.	Test Run	Veh. Speed (mph)	Veh. Freq. (vph)	Type and Location of Air Samples Analyzed									Total No. of Samples
				1	2	3	4	5	6	7	8	9	
1	1	0	0			■	■		■				3
1	2	10	45	■	■								2
1	3	25	15			■	■	■	■	■		■	6
1	4	10	15										0*
1	5	25	5			■	■	■	■	■		■	6
1	6	25	45			■	■	■	■	■		■	6
1	7	10	15			■	■	■	■	■		■	6
1	8	10	45			■	■	■	■	■		■	6
2	1	0	0			■	■		■		◆		4
2	2	25	45	■	■	■	■	■	■	■		■	8
2	3	10	45			■	■	■	■	■		■	6
2	4	25	15			■	■	■	■	■		■	6
2	5	10	15			■	■	■	■	■	◆	■	7
2	6	25	5			■	■	■	■	■		■	6
2	7	10	5			■	■	■	■	■		■	6
3	1	0	0			■	■		■				3
3	2	10	45	■	■	■	■	■	■	■		■	8
3	3	25	15			■	■	■	■	■		■	6
3	4	10	15			■	■	■	■	■		■	6
3	5	25	5			■	■	■	■	■		■	6
3	6	10	5			■	■	■	■	■		■	6
3	7	10	45			■	■	■	■	■		■	6
4	1	0	0			■	■		■				3
4	2	25	45	■	■	■	■	■	■	■		■	8
4	3	25	15			■	■	■	■	■		■	6
4	4	25	5										0*
4	5	10	5										0*

Samplers:

1. Field Blank
2. Lab Blank
3. Upwind 50'/1.5m
4. Downwind 25'/1.5m
5. Downwind 25'/3m
6. Downwind 75'/1.5m
7. Downwind 250'/1.5m
8. Downwind 1100'/1.5m
9. Replicate (floating)

■ One hour sample
◆ Continuous sample (all day)
*Due to poor wind conditions

Table 3-3. SUMMARY OF TEST CONDITIONS AND TEM-MEASURED ASBESTOS CONCENTRATIONS AT EACH STUDY SITE

Study Site	Test Run	Veh. Speed (mph)	Veh. Freq. (vph)	TEM0 (struc./cc)	
				Upwind	Downwind
1	1	0	0	.02	.01 - .08
1	4, 7	10	15	.01	.15 - .44
1	2, 8	10	45	.14	.59 - 1.87
1	5	25	5	.01	.25 - 7.25
1	3	25	15	.02	.94 - 3.23
1	6	25	45	.02	3.83 - 10.04
2	1	0	0	.01	.01
2	7	10	5	.01	.00* - .21
2	5	10	15	.01	.00* - 1.34
2	3	10	45	.01	.03* - 2.07
2	6	25	5	.02	.00* - 3.99
2	4	25	15	.05	.04* - 4.10
2	2	25	45	.01	.00 - 9.57
3	1	0	0	.02	.04 - .11
3	6	10	5	.01	.04 - .17
3	4	10	15	.02	.10 - .56
3	2, 7	10	45	.01 - .02	.05 - 4.01
3	5	25	5	.01	.47 - 1.66
3	3	25	15	.04	.55 - 7.59
4	1	0	0	.02	.02 - .05
4	3	25	15	.01	1.05 - 5.28
4	2	25	45	.01	2.65 - 14.20

* At 1100 ft downwind

Table 3-4. SUMMARY OF AIR AND BULK SAMPLE ANALYSIS RESULTS

	DATE	RUN	TIME START	VEH. SPEED (MPH)	VEH. FREQ. (VPH)	STAB. CLASS	SAMPLER DIST. (FT)	SAMPLER HEIGHT (M)	BULK ASB. CONT^a	MOIS-TURE CONT^b	SILT CONT^b	PCM CONC^c (F/CC)	TEM-MEASURED CONC. >=5u (STRUC/CC)	ALL (STRUC/CC)
SITE 1														
	8/19/91	1	13:55	0	0	B	50	1.5	14.0	.3	4.8	.01	0.00	.02
	8/19/91	1	13:55	0	0	B	25	1.5	14.0	.3	4.8	.01	.02	.08
	8/19/91	1	13:55	0	0	B	75	1.5	14.0	.3	4.8	.01	.01	.01
	8/19/91	3	17:40	25	15	B	50	1.5	14.0	.1	8.0	.01	0.00	.02
	8/19/91	3	17:40	25	15	B	25	1.5	14.0	.1	8.0	.02	.24	3.23
	8/19/91	3	17:40	25	15	B	25	3.0	14.0	.1	8.0	.02	.06	1.38
	8/19/91	3	17:40	25	15	B	75	1.5	14.0	.1	8.0	.02	.02	.94
	8/19/91	3	17:40	25	15	B	250	1.5	14.0	.1	8.0	.01	.04	1.42
	8/19/91	3	17:40	25	15	B	75	1.5	14.0	.1	8.0	.01	.10	2.56
	8/20/91	5	14:28	25	5	C	50	1.5	14.0	.4	9.3	.01	0.00	.01
	8/20/91	5	14:28	25	5	C	25	1.5	14.0	.4	9.3	.05	.32	7.25
	8/20/91	5	14:28	25	5	C	25	3.0	14.0	.4	9.3	.01	.07	1.67
	8/20/91	5	14:28	25	5	C	75	1.5	14.0	.4	9.3	.02	.14	3.59
	8/20/91	5	14:28	25	5	C	250	1.5	14.0	.4	9.3	.01	.01	.25
	8/20/91	5	14:28	25	5	C	25	1.5	14.0	.4	9.3	.06	.27	5.47
	8/20/91	6	17:08	25	45	C	50	1.5	14.0	.6	6.9	.01	0.00	.02
	8/20/91	6	17:08	25	45	C	25	1.5	14.0	.6	6.9	.15	.94	9.12
	8/20/91	6	17:08	25	45	C	25	3.0	14.0	.6	6.9	.10	.47	4.67
	8/20/91	6	17:08	25	45	C	75	1.5	14.0	.6	6.9	.08	.48	5.41
	8/20/91	6	17:08	25	45	C	250	1.5	14.0	.6	6.9	.05	.34	3.83
	8/20/91	6	17:08	25	45	C	75	1.5	14.0	.6	6.9	.07	.65	10.04
	8/23/91	7	12:35	10	15	B	50	1.5	14.0	.8	9.9	.01	0.00	.01
	8/23/91	7	12:35	10	15	B	25	1.5	14.0	.8	9.9	.01	.02	.44
	8/23/91	7	12:35	10	15	B	25	3.0	14.0	.8	9.9	.01	.32	.37
	8/23/91	7	12:35	10	15	B	75	1.5	14.0	.8	9.9	.01	.03	.26
	8/23/91	7	12:35	10	15	B	250	1.5	14.0	.8	9.9	.01	0.00	.15
	8/23/91	7	12:35	10	15	B	25	1.5	14.0	.8	9.9	.01	0.00	.06
	8/23/91	8	14:00	10	45	B	50	1.5	14.0	.7	9.9	.01	.01	.14
	8/23/91	8	14:00	10	45	B	25	1.5	14.0	.7	9.9	.02	.18	1.87
	8/23/91	8	14:00	10	45	B	25	3.0	14.0	.7	9.9	.02	.05	1.27
	8/23/91	8	14:00	10	45	B	75	1.5	14.0	.7	9.9	.01	.07	.77
	8/23/91	8	14:00	10	45	B	250	1.5	14.0	.7	9.9	.01	.03	.59
	8/23/91	8	14:00	10	45	B	25	1.5	14.0	.7	9.9	.01	.17	1.76
SITE 2														
	8/21/91	1	13:35	0	0	B	50	1.5	14.0	.3	4.9	.01	0.00	.01
	8/21/91	1	13:35	0	0	B	25	1.5	14.0	.3	4.9	.01	0.00	.01
	8/21/91	1	13:35	0	0	B	75	1.5	14.0	.3	4.9	.01	0.00	.01
	8/21/91	2	14:40	25	45	B	50	1.5	14.0	.5	4.8	.01	0.00	.01
	8/21/91	2	14:40	25	45	B	25	1.5	14.0	.5	4.8	.09	1.57	9.57
	8/21/91	2	14:40	25	45	B	25	3.0	14.0	.5	4.8	.07	.41	5.00
	8/21/91	2	14:40	25	45	B	75	1.5	14.0	.5	4.8	.06	.32	5.78
	8/21/91	2	14:40	25	45	B	250	1.5	14.0	.5	4.8	.02	.05	1.66
	8/21/91	2	14:40	25	45	B	1100	1.5	14.0	.5	4.8	.00	.01	.04
	8/21/91	2	14:40	25	45	B	25	1.5	14.0	.5	4.8	.10	.81	6.15
	8/21/91	3	15:52	10	45	C	50	1.5	14.0	.2	4.5	.01	0.00	.01
	8/21/91	3	15:52	10	45	C	25	1.5	14.0	.2	4.5	.02	.17	1.74
	8/21/91	3	15:52	10	45	C	25	3.0	14.0	.2	4.5	.01	.18	2.11
	8/21/91	3	15:52	10	45	C	75	1.5	14.0	.2	4.5	.02	.15	2.07
	8/21/91	3	15:52	10	45	C	250	1.5	14.0	.2	4.5	.01	.04	.46
	8/21/91	3	15:52	10	45	C	1100	1.5	14.0	.2	4.5	.00	.01	.04

Table 3-4 (continued) - 2

DATE	RUN	TIME START	VEH. SPEED (MPH)	VEH. FREQ. (VPH)	STAB. CLASS	SAMPLER DIST. (FT)	SAMPLER HEIGHT (M)	BULK ASB. CONT^a	MOIS-TURE CONT^b	SILT CONT^b	PCM CONC^c (F/CC)	TEM-MEASURED CONC. >=5u (STRUC/CC)	ALL (STRUC/CC)
8/21/91	3	15:52	10	45	C	75	1.5	14.0	.2	4.5	.01	.22	2.04
8/21/91	4	17:10	25	15	C	50	1.5	14.0	.2	5.9	.01	0.00	.05
8/21/91	4	17:10	25	15	C	25	1.5	14.0	.2	5.9	.03	.42	4.35
8/21/91	4	17:10	25	15	C	25	3.0	14.0	.2	5.9	.02	.29	4.10
8/21/91	4	17:10	25	15	C	75	1.5	14.0	.2	5.9	.04	.22	2.41
8/21/91	4	17:10	25	15	C	250	1.5	14.0	.2	5.9	.01	.06	1.31
8/21/91	4	17:10	25	15	C	1100	1.5	14.0	.2	5.9	.00	.01	.04
8/21/91	4	17:10	25	15	C	250	1.5	14.0	.2	5.9	.01	.19	1.17
8/22/91	5	13:05	10	15	B	50	1.5	14.0	.3	5.5	.01	0.00	.01
8/22/91	5	13:05	10	15	B	25	1.5	14.0	.3	5.5	.01	.03	.77
8/22/91	5	13:05	10	15	B	25	3.0	14.0	.3	5.5	.01	.02	1.34
8/22/91	5	13:05	10	15	B	75	1.5	14.0	.3	5.5	.01	.04	.56
8/22/91	5	13:05	10	15	B	250	1.5	14.0	.3	5.5	.01	.01	.09
8/22/91	5	13:05	10	15	B	1100	1.5	14.0	.3	5.5	.01	.01	.01
8/22/91	5	13:05	10	15	B	50	1.5	14.0	.3	5.5	.01	0.00	.01
8/22/91	6	14:35	25	5	B	50	1.5	14.0	.3	6.1	.01	0.00	.02
8/22/91	6	14:35	25	5	B	25	1.5	14.0	.3	6.1	.03	.25	3.90
8/22/91	6	14:35	25	5	B	25	3.0	14.0	.3	6.1	.01	.21	2.52
8/22/91	6	14:35	25	5	B	75	1.5	14.0	.3	6.1	.01	.08	1.32
8/22/91	6	14:35	25	5	B	250	1.5	14.0	.3	6.1	.01	.05	.46
8/22/91	6	14:35	25	5	B	1100	1.5	14.0	.3	6.1	.01	.01	.01
8/22/91	6	14:35	25	5	B	25	1.5	14.0	.3	6.1	.02	.38	3.99
8/22/91	7	15:55	10	5	B	50	1.5	14.0	.3	5.6	.01	0.00	.01
8/22/91	7	15:55	10	5	B	25	1.5	14.0	.3	5.6	.01	.03	.21
8/22/91	7	15:55	10	5	B	25	3.0	14.0	.3	5.6	.01	.01	.11
8/22/91	7	15:55	10	5	B	75	1.5	14.0	.3	5.6	.01	0.00	.08
8/22/91	7	15:55	10	5	B	250	1.5	14.0	.3	5.6	.01	0.00	.01
8/22/91	7	15:55	10	5	B	1100	1.5	14.0	.3	5.6	.01	.01	.01
8/22/91	7	15:55	10	5	B	75	1.5	14.0	.3	5.6	.01	0.00	.06
SITE 3													
9/12/91	1	11:50	0	0	B	50	1.5	18.3	.8	6.9	.01	0.00	.02
9/12/91	1	11:50	0	0	B	25	1.5	18.3	.8	6.9	.01	.01	.11
9/12/91	1	11:50	0	0	B	75	1.5	18.3	.8	6.9	.01	0.00	.04
9/12/91	2	14:50	10	45	B	50	1.5	18.3	1.9	5.6	.01	0.00	.03
9/12/91	2	14:50	10	45	B	25	1.5	18.3	1.9	5.6	.01	.08	1.22
9/12/91	2	14:50	10	45	B	25	3.0	18.3	1.9	5.6	.01	.02	.88
9/12/91	2	14:50	10	45	B	75	1.5	18.3	1.9	5.6	.01	.06	.84
9/12/91	2	14:50	10	45	B	250	1.5	18.3	1.9	5.6	.01	.01	.21
9/12/91	2	14:50	10	45	B	50	1.5	18.3	1.9	5.6	.01	0.00	.05
9/12/91	3	15:52	25	15	B	50	1.5	18.3	1.5	10.3	.01	0.00	.05
9/12/91	3	15:52	25	15	B	25	1.5	18.3	1.5	10.3	.05	.09	8.32
9/12/91	3	15:52	25	15	B	25	3.0	18.3	1.5	10.3	.02	.28	3.43
9/12/91	3	15:52	25	15	B	75	1.5	18.3	1.5	10.3	.05	.29	2.42
9/12/91	3	15:52	25	15	B	250	1.5	18.3	1.5	10.3	.01	.03	.55
9/12/91	3	15:52	25	15	B	25	1.5	18.3	1.5	10.3	.05	.35	5.33
9/13/91	4	12:12	10	15	A	50	1.5	18.3	1.2	6.4	.01	0.00	.02
9/13/91	4	12:12	10	15	A	25	1.5	18.3	1.2	6.4	.01	.02	.56
9/13/91	4	12:12	10	15	A	25	3.0	18.3	1.2	6.4	.01	0.00	.39
9/13/91	4	12:12	10	15	A	75	1.5	18.3	1.2	6.4	.01	.02	.11
9/13/91	4	12:12	10	15	A	250	1.5	18.3	1.2	6.4	.01	0.00	.10
9/13/91	4	12:12	10	15	A	75	1.5	18.3	1.2	6.4	.01	.01	.14

Table 3-4 (continued) - 3

DATE	RUN	TIME START	VEH. SPEED (MPH)	VEH. FREQ. (VPH)	STAB. CLASS	SAMPLER DIST. (FT)	SAMPLER HEIGHT (M)	BULK ASB. CONT[a]	MOIS-TURE CONT[b]	SILT CONT[b]	PCM CONC[c] (F/CC)	TEM-MEASURED CONC. >=5u (STRUC/CC)	ALL (STRUC/CC)
9/13/91	5	13:21	25	5	B	50	1.5	18.3	1.4	7.4	.01	0.00	.01
9/13/91	5	13:21	25	5	B	25	1.5	18.3	1.4	7.4	.02	.12	1.66
9/13/91	5	13:21	25	5	B	25	3.0	18.3	1.4	7.4	.02	.09	1.05
9/13/91	5	13:21	25	5	B	75	1.5	18.3	1.4	7.4	.01	.03	.74
9/13/91	5	13:21	25	5	B	250	1.5	18.3	1.4	7.4	.01	.03	.47
9/13/91	5	13:21	25	5	B	250	1.5	18.3	1.4	7.4	.01	.04	.51
9/13/91	6	14:28	10	5	B	50	1.5	18.3	1.2	6.4	.01	0.00	.01
9/13/91	6	14:28	10	5	B	25	1.5	18.3	1.2	6.4	.01	.01	.17
9/13/91	6	14:28	10	5	B	25	3.0	18.3	1.2	6.4	.01	0.00	.05
9/13/91	6	14:28	10	5	B	75	1.5	18.3	1.2	6.4	.01	.02	.15
9/13/91	6	14:28	10	5	B	250	1.5	18.3	1.2	6.4	.01	0.00	.04
9/13/91	6	14:28	10	5	B	25	3.0	18.3	1.2	6.4	.01	0.00	.04
9/13/91	7	15:40	10	45	C	50	1.5	18.3	.4	7.4	.01	0.00	.01
9/13/91	7	15:40	10	45	C	25	1.5	18.3	.4	7.4	.03	.24	4.01
9/13/91	7	15:40	10	45	C	25	3.0	18.3	.4	7.4	.01	.03	.77
9/13/91	7	15:40	10	45	C	75	1.5	18.3	.4	7.4	.01	.12	1.16
9/13/91	7	15:40	10	45	C	250	1.5	18.3	.4	7.4	.01	.01	.39
SITE 4													
9/14/91	1	11:48	0	0	B	50	1.5	16.7	.7	7.8	.01	0.00	.02
9/14/91	1	11:48	0	0	B	25	1.5	16.7	.7	7.8	.01	0.00	.02
9/14/91	1	11:48	0	0	B	75	1.5	16.7	.7	7.8	.01	0.00	.05
9/14/91	2	13:47	25	45	B	50	1.5	16.7	.7	7.1	.01	0.00	.01
9/14/91	2	13:47	25	45	B	25	1.5	16.7	.7	7.1	.14	1.10	14.20
9/14/91	2	13:47	25	45	B	25	3.0	16.7	.7	7.1	.09	.52	6.64
9/14/91	2	13:47	25	45	B	75	1.5	16.7	.7	7.1	.12	.24	6.72
9/14/91	2	13:47	25	45	B	250	1.5	16.7	.7	7.1	.02	.22	3.86
9/14/91	2	13:47	25	45	B	250	1.5	16.7	.7	7.1	.03	.12	2.66
9/14/91	3	15:45	25	15	B	50	1.5	16.7	.5	8.4	.01	0.00	.01
9/14/91	3	15:45	25	15	B	25	1.5	16.7	.5	8.4	.07	.07	5.28
9/14/91	3	15:45	25	15	B	25	3.0	16.7	.5	8.4	.03	.04	2.64
9/14/91	3	15:45	25	15	B	75	1.5	16.7	.5	8.4	.03	.12	2.34
9/14/91	3	15:45	25	15	B	250	1.5	16.7	.5	8.4	.01	.10	1.05
9/14/91	3	15:45	25	15	B	75	1.5	16.7	.5	8.4	.03	.07	2.18

---

[a] Bulk asbestos content in percent, determined by the mean of three composite samples of the road surface material.

[b] In percent

[c] Phase contrast microscopy measured asbestos concentration

of the samples respectively. Non-chrysotile structures including Antigorite generally occurred at a rate of about 1% of chrysotile structures.

3.3 METEOROLOGICAL CONDITIONS

Table 3-5 summarizes the meteorological conditions experienced each day of testing at each study site. Note that data recording for each day began upon site arrival, usually 9 to 11 A.M., and ended upon site departure, usually 5 to 7 P.M. Therefore these values represent highs, lows, and means of the meteorological parameters during this period, not true daily highs, lows, and means.

Table 3-6 summarizes the wind conditions experienced for each testing run at each study site. Items included are mean wind speed, mean wind direction, and standard deviation of wind direction.

Table 3-5. SUMMARY OF METEOROLOGICAL CONDITIONS MEASURED ON EACH STUDY DAY

Site No.	Date	Relative Humidity		Temperature		Avg. Wind Speed (m/s)	Avg. Wind Direction
		Low	High	Low	High		
1	8/19/91	38%	51%	81.4	89.3	4.0	298°
1	8/20/91	24%	49%	73.3	91.6	4.3	297°
1	8/23/91	37%	47%	80.7	92.9	3.4	275°
2	8/21/91	20%	44%	79.5	93.0	3.8	286°
2	8/22/91	29%	44%	82.1	91.5	3.9	295°
3	9/12/91	37%	53%	78.7	93.5	2.5	265°
3	9/13/91	41%	61%	74.0	91.1	2.4	273°
4	9/14/91	40%	53%	77.8	86.4	3.1	289°
4	9/15/91	51%	63%	74.1	85.7	2.4	283°

Table 3-6. SUMMARY OF WIND CONDITIONS MEASURED FOR EACH TEST RUN

Site No.	Test Run	Mean Wind Speed (m/s)	Mean Wind Direction	Standard Dev. of Wind Dir.
1	1	4.0	301	10.4
1	3	4.1	293	6.3
1	5	4.2	297	11.7
1	6	4.5	294	7.2
1	7	3.4	288	21.1
1	8	3.1	260	12.4
2	1	3.6	280	13.4
2	2	3.3	285	16.8
2	3	3.8	280	10.8
2	4	4.3	283	7.5
2	5	4.0	296	11.1
2	6	3.7	292	11.7
2	7	3.9	290	12.3
3	1	2.2	255	19.6
3	2	2.5	268	17.4
3	3	2.9	288	11.7
3	4	1.2	263	45.6
3	5	2.3	249	15.7
3	6	3.1	269	14.1
3	7	3.5	282	9.8
4	1	3.1	293	13.1
4	2	3.2	303	16.2
4	3	3.3	306	12.9

3.4 QUALITY ASSURANCE FOR AIR SAMPLES

To ensure that the field experiments would yield scientifically valid air samples, the following types of quality assurance data samples were taken:

(1) Four laboratory blanks and four field blanks to ensure that all filter cassettes used for air sampling were neither contaminated nor mishandled.

(2) A total of 12 air samples with no traffic on the test road segments (2 air samples at downwind distances of 25' and 75' and 1 at an upwind distance of 50', for each of the 4 study sites) to determine the spatial distribution of background asbestos concentrations.

(3) A total of 21 upwind air samples with traffic on the test road segments to determine the asbestos concentrations in in-coming wind.

(4) A total of 18 replicate air samples taken by a floating sampler that was collocated with one of the primary samplers at 1.5 m or 3.0 m above the ground in order to determine the reproducibility of ambient asbestos concentration measurements. Collocated sampler results are provided in Appendix A.

(5) Two distant air samplers at 1100 feet downwind at Site 2 for two 5-hour periods to determine the downwind extent of traffic-induced road dust.

As to the laboratory and field blanks, none of the blank samples were found to contain any structures above the detection limit of transmission electron microscopy. This provided assurance that the filter cassettes used in the field experiments were indeed not contaminated.

In addition to the quality assurance measures listed above, all results were further verified by checking the consistency of data and examining all anomalous values. Although some values were identified that did not meet expected patterns (e.g., run 3 at site 3 where the TEM0 concentration at 3m was higher than at 1.5m), none were judged to be outside the range of plausibility.

Table 3-7 provides comparisons of ambient asbestos concentrations under three background conditions and two test conditions:

Background Condition

- No traffic
- Upwind receptors with traffic
- Remote receptors with traffic

Test Condition

- Downwind receptors at 1.5 m with traffic
- Downwind receptors at 3.0 m with traffic

The table shows that mean concentrations under the three background conditions (0.022 - 0.032 struc/cc) are only about a hundredth of those under the two test conditions (2.11 and 2.43). Because of this extremely low asbestos concentration level, the three background conditions (i.e., no traffic, upwind and 1100 ft downwind with traffic) indeed were judged to provide background asbestos concentrations.

Concentration values listed in Table 3-7 are for TEM0 -- all structures having ≥ 3-to-1 aspect ratio regardless of size. More conventional TEM5 (structures greater than 5 micrometers with ≥ 3-to-1 aspect ratio) concentrations were an order of magnitude lower than TEM0 concentrations. Since TEM5 concentrations under the three background conditions were below or around the TEM detection limit, the background asbestos levels exemplified by those under the three background conditions were judged to be negligible as compared to asbestos concentrations of the two test conditions -- in immediate downwind area with considerable traffic.

Asbestos concentrations of each pair of two collocated air samples (i.e., "replicate" vs "primary") are compared in Figures 3-1 and 3-2. Figure 3-1 shows TEM0 concentrations of 18 replicate samples taken by the floating sampler and those of the corresponding primary samples taken at upwind (2 samples) and downwind (16 samples) locations. The near symmetric scatter around the 1-to-1 line in the figure indicates a good reproducibility of ambient asbestos measurement by our sampling and TEM analysis methods. Although there is moderate scatter (indicating some random error), no particular trend is present (indicating negligible systematic error). Figure 3-2 shows the same pairs of data for TEM5 concentrations. This figure also exhibits a symmetric scatter around the 1-to-1 line, indicating no biases in either the sampling method or the analysis method used.

Table 3-7. COMPARISON OF BACKGROUND ASBESTOS CONCENTRATIONS WITH DOWNWIND ASBESTOS CONCENTRATIONS.

Background (B)/ Test (T) Conditions	Sample Size	TEM0, struc/cc				
		min	max	median	mean	s.d.
B: No traffic (both upwind & downwind)	12	.009	.114	.019	.032	.033
B: Upwind w/ traffic	21	.009	.139	.010	.024	.030
B: Remote Sample (at 1100 ft) w/ traffic	2	.009	.035	n/a	.022	.019
T: Downwind at 1.5m above the ground w/ traffic	72	.009	14.200	1.314	2.434	2.864
T: Downwind at 3.0m above the ground w/ traffic	19	.047	6.642	1.380	2.109	1.850

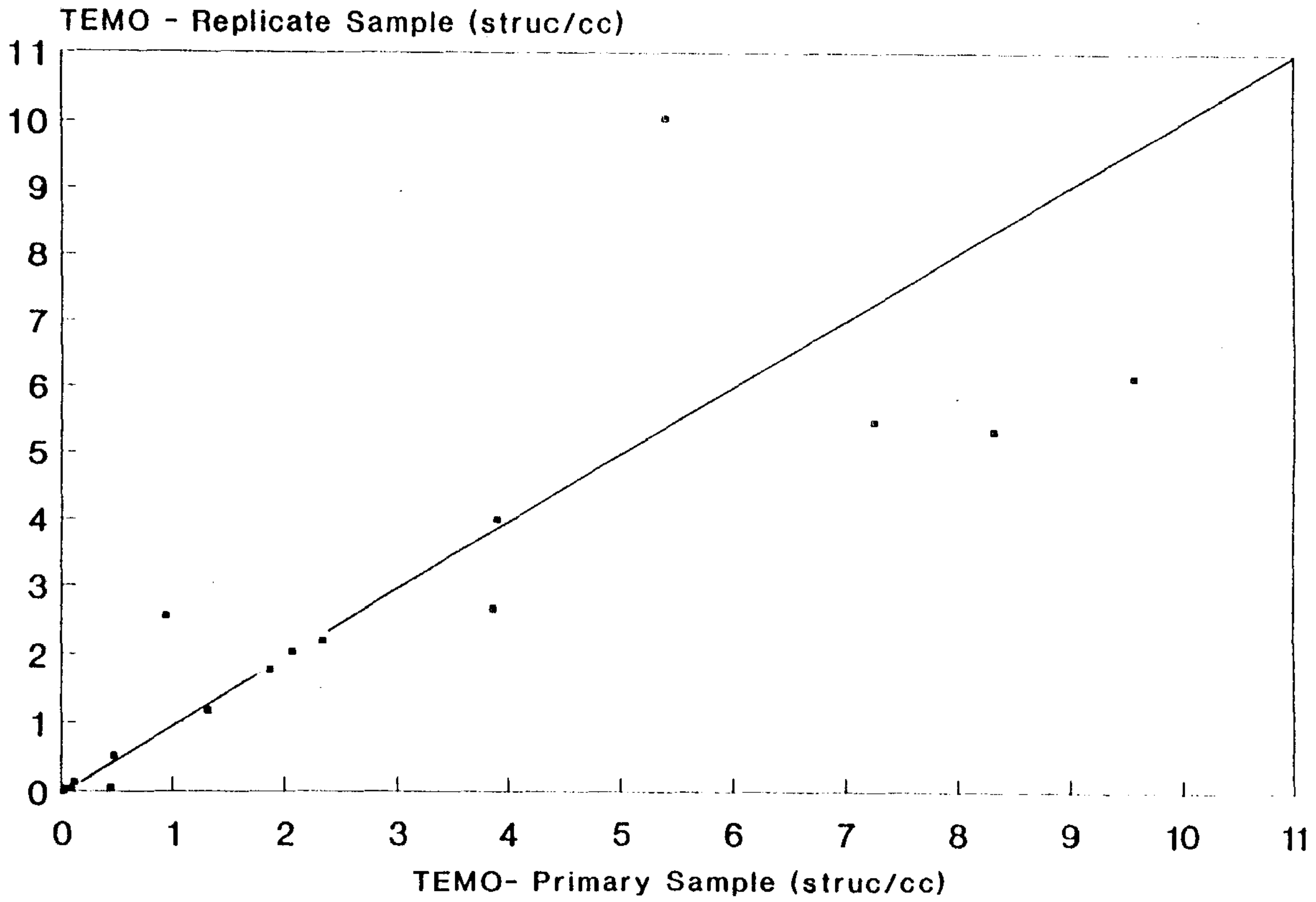

Figure 3-1. Comparison of TEM0 Asbestos Concentrations of Replicate Samples with those of Primary Samples (n = 18).

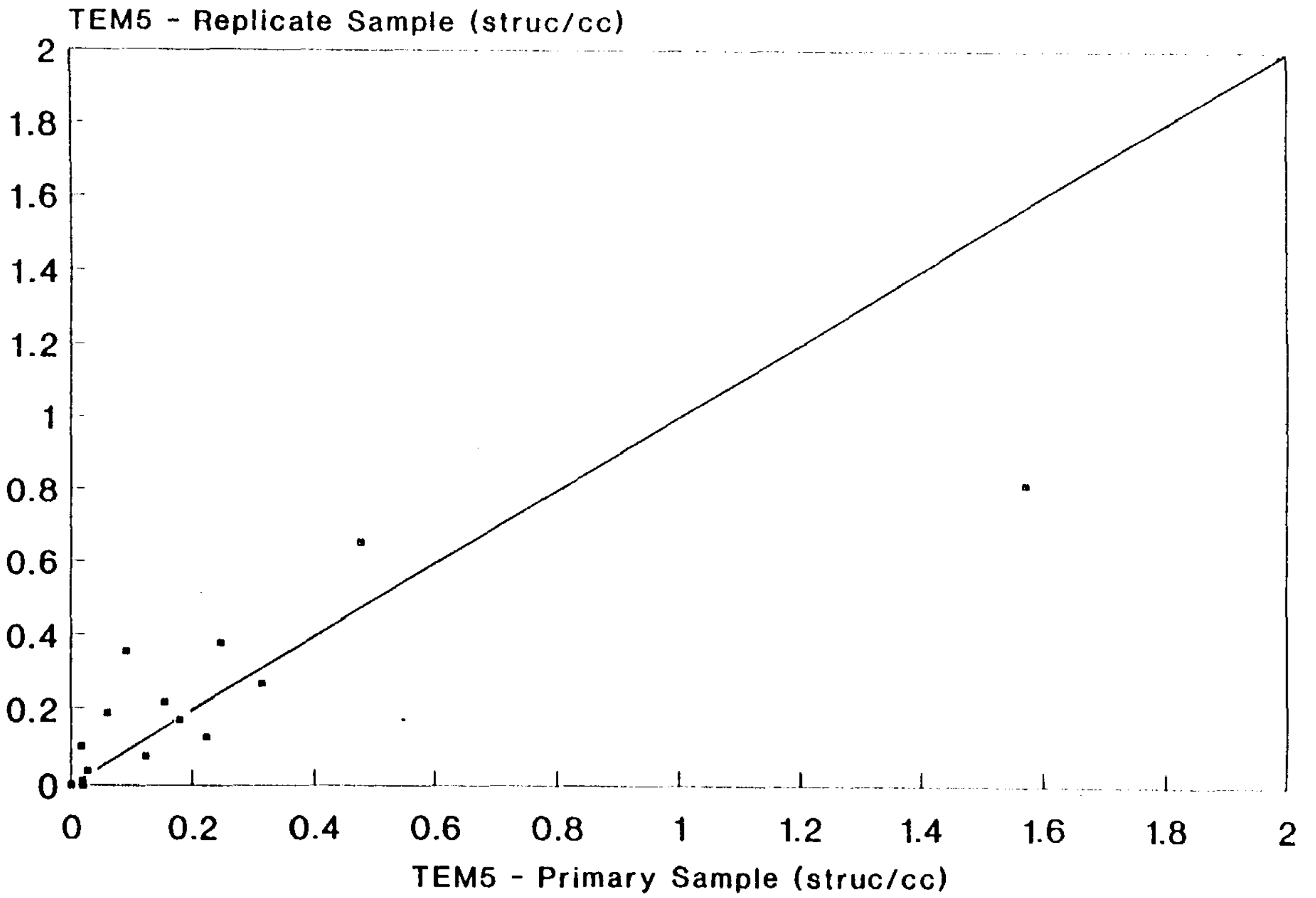

Figure 3-2. Comparison of TEM5 Asbestos Concentrations of Replicate Samples with those of Primary Samples (n = 18).

Figure 3-3 shows a scattergram of downwind (at 25 feet) asbestos concentrations at two different heights: 1.5 m and 3.0 m above the ground. It exhibits fairly high correlation between concentrations at 1.5 m and 3.0 m. To check whether the correlation exhibited in measured concentrations at 1.5 m and 3.0 m is reasonable, a theoretical ratio of concentrations at the two heights was computed according to the following equation:

$$\frac{A_{1.5}}{A_0} - \exp\left[-\frac{1}{2}\left(\frac{1.5}{\sigma_z}\right)^2\right] \tag{3-1}$$

where $A_{1.5}$ is a theoretical concentration at 1.5 m above the ground, A_0 is a theoretical concentration on the ground, and σ_z is a vertical dispersions parameter. The reason for using 1.5 m and 0 m in the equation is that samplers at 1.5 m in the field experiment were presumed to represent virtual ground-level concentrations to which people are exposed.

Theoretical concentration ratios were computed using actual wind and stability conditions that existed at the 19 data points. Then, the theoretical ratios were compared with ratios of measured asbestos concentrations at 1.5 m and 3.0 m. Table 3-8 shows such comparisons. In general, the theoretical ratios of concentrations at the two heights are in good agreement with those calculated from measured asbestos concentrations. One noticeable difference between the theoretical and measured ratios is that the latter exhibit much wider variation in the ratio values than the theoretical ones.

Judging from the quality assurance data samples described hitherto, the field experiments seem to have generated reasonable scientific data of ambient asbestos concentrations around a serpentine-covered unpaved roadway.

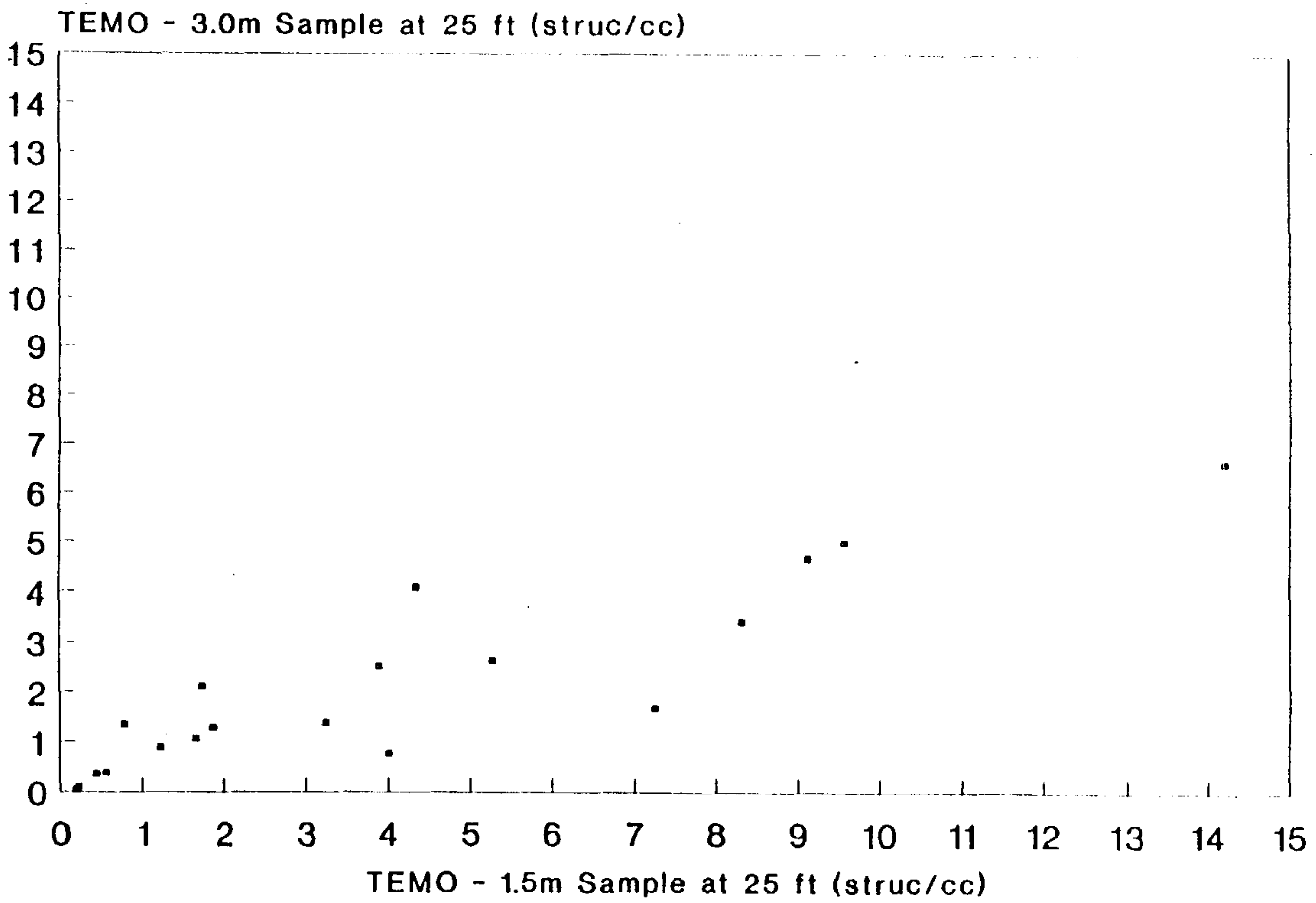

Figure 3-3. Downwind Asbestos Concentrations at 3.0 m and 1.0 m (n = 19).

Table 3-8. COMPARISON OF MEASURED RATIOS AND THEORETICAL RATIOS OF ASBESTOS CONCENTRATIONS AT 3.0 M TO THOSE AT 1.5 M ABOVE THE GROUND.

	Theoretical Ratio	Measured Ratio	
		TEM0	TEM5
Number of Cases	19	19	19
Minimum	0.34	0.19	0.00
Maximum	0.66	1.73	16.03
Median	0.61	0.52	0.47
Mean	0.57	0.64	1.39

4.0 EVALUATION OF EPA MODEL PERFORMANCE

4.1 COMPARISON OF MEASURED vs PREDICTED CONCENTRATIONS

As a preliminary step for evaluating and improving EPA's roadway asbestos concentration model, we compared asbestos concentrations observed in the field experiments with concentrations predicted by the model. The comparisons were made for two types of TEM-measured concentrations: TEM0 (total structures having ≥ 3-to-1 aspect ratios regardless of size) and TEM5 (structures ≥ 5 μm in length). These two number concentrations are reported as number of structures per cubic centimeter of air (struc/cc). The EPA model predicts number concentrations for structures ≥ 5 μm only, namely TEM5, which are considered to be PCM equivalent concentrations. PCM-based airborne asbestos exposure standards are given in Appendix B.

4.1.1 DESCRIPTION OF DATA SET USED FOR EVALUATION

Table 4-1 summarizes the number of TEM-analyzed air samples collected during the field experiments. The complete data set consists of 125 asbestos concentrations and corresponding sampler locations and traffic and weather conditions. This data set comes from test runs at all four study sites near Oakdale and excludes three test runs with unfavorable wind conditions.

Table 4-1. NUMBER OF ANALYZED ASBESTOS SAMPLES BY LOCATION[1]

Sample Location	Background	With Traffic
Downwind, 1.5m height	8	72[2]
Upwind, 1.5m height	4	21
Downwind, 3m height	0	20
Total	12	113

[1] Excluding field blanks, lab blanks, and distant samples.

[2] 64 of these above detection limit for TEM5.

Of the 125 data points, 12 are background samples and the other 113 represent samples taken during traffic simulation. Since the model does not predict concentrations in the absence of traffic, background samples were excluded from preliminary analyses. Of the 113 with-traffic samples, only the 72 samples located downwind at 1.5 m height were used for this analysis. This excludes 21 upwind samples and 20 downwind samples at the 3 m sampling height.

The final set of 72 samples includes samples collected at downwind distances of 25 ft., 75 ft., and 250 ft. from the center line of the test roadways. For use as model inputs, the actual distance travelled by the plume was calculated by dividing the sampler distance from the roadway by the cosine of the wind direction's deviation from the perpendicular path to the roadway using:

$$x = \frac{x'}{\cos(DEV)} \qquad (4\text{-}1)$$

Here x = distance travelled by the plume
x' = sampler distance from roadway
DEV = wind direction's deviation from perpendicular path

All 72 samples in the data set were used in TEM0 model analyses. However, 8 data points were excluded from the TEM5 model analyses because of concentrations below detection limits. The complete set including these 72 data points is given in Table 3-4.

4.1.2 COMPARISON OF RESULTS WITH EPA MODEL PREDICTIONS

Model calculations were performed using the EPA model, which is an expanded version of the Copeland Model that incorporates elements of a Gaussian line-source dispersion model and the original Copeland Model for dust emissions from unpaved roads:

$$A = 1.7\,k\,\frac{2}{(2\pi)^{0.5}}\,\frac{S}{12}\,\frac{V}{48}\left(\frac{W}{2.7}\right)^{0.7}\left(\frac{WH}{4}\right)^{0.5}\frac{AC}{100}\,\frac{n}{\sigma_z}\,\frac{CF}{U}\,\frac{365-p}{365} \qquad (4\text{-}2)$$

where A = TEM5 airborne asbestos concentration (struc/cc)
k = aerodynamic particle size multiplier
S = silt content of road surface (%)
V = vehicle speed (km/h)
W = vehicle weight (Mg=megagrams)
WH = number of wheels
AC = asbestos content of road surface (%)
n = vehicle frequency (no. of vehicle passes/s)
σ_z = vertical dispersion parameter (m)
CF = conversion factor (assumes 3×10^{10} struc/g of asbestos)
U = wind speed (m/s)
p = average number of days per year with ≥0.01 inches of precipitation

The vertical dispersion parameter σ_z was calculated using the equation:

$$\sigma_z = (\sigma_z'^2 + H^2)^{0.5} \tag{4-3}$$

where H is an estimate of the initial vertical dispersion of the vehicle wake (in this case it was set to 1 m, or about half the vehicle height) and where σ_z' is calculated as:

$$\sigma_z' = A\,x^B + C \tag{4-4}$$

where A, B, and C are constants as defined in Table 4-2.

Four model parameters were kept constant for all model runs. The average number of days per year with greater than 0.01 inches of precipitation was not known for Oakdale, so the value for Stockton (51 days) was used. The particle-size multiplier (k) was kept at the default value of 0.36, which is for particles ≤10 µm in accordance with AP-42. Vehicle weight was kept at 1.8 tons, which is the unladen weight of the test van. The number of wheels was kept at 4.

Table 4-2. CONSTANTS FOR VERTICAL DISPERSION PARAMETER

Stability Class	Distance ≤ 100 m			Distance > 100 m and < 153 m		
	A	B	C	A	B	C
A	0.192	0.936	0.0	0.00066	1.941	9.3
B	0.156	0.922	0.0	0.0382	1.149	3.3
C	0.116	0.905	0.0	0.113	0.911	0.0
D	0.079	0.881	0.0	0.222	0.725	-1.7
E	0.063	0.871	0.0	0.211	0.678	-1.3
F	0.053	0.814	0.0	0.086	0.740	-0.35

4.1.3 RESULTS OF THE COMPARISON

Figure 4-1 shows a comparison of model-predicted TEM5 concentrations vs measured TEM0 concentrations (all structures). The predicted concentrations are short of the measured concentrations by about an order of magnitude. Figure 4-2 shows the comparison using TEM5 data. This shows a better agreement in magnitude between predicted and measured concentrations, but exhibits a weaker association than that shown in Figure 4-1.

Figure 4-3 shows the comparison between model-predicted TEM5 concentrations and measured TEM5 concentrations at the two vehicle speeds used in the test runs. At 10 mph, the model overpredicts concentrations by about 300%, while at 25 mph the model-predicted and measured concentrations show reasonable agreement. Linear regressions were determined for the data shown in figures 4-1 through 4-3 in two ways: (1) with a non-zero intercept and (2) with a zero intercept. Regression statistics are given in Table 4-3. It should be noted that regressions with no intercept consistently perform better than those including an intercept. This implies that measured asbestos concentrations would be better explained by a multiplicative correction term to the EPA model rather than by an additive correction term.

Figure 4-4a shows the concentration profile of measured TEM5 airborne asbestos along downwind distance. Figure 4-4b shows the same profile for model-predicted TEM5

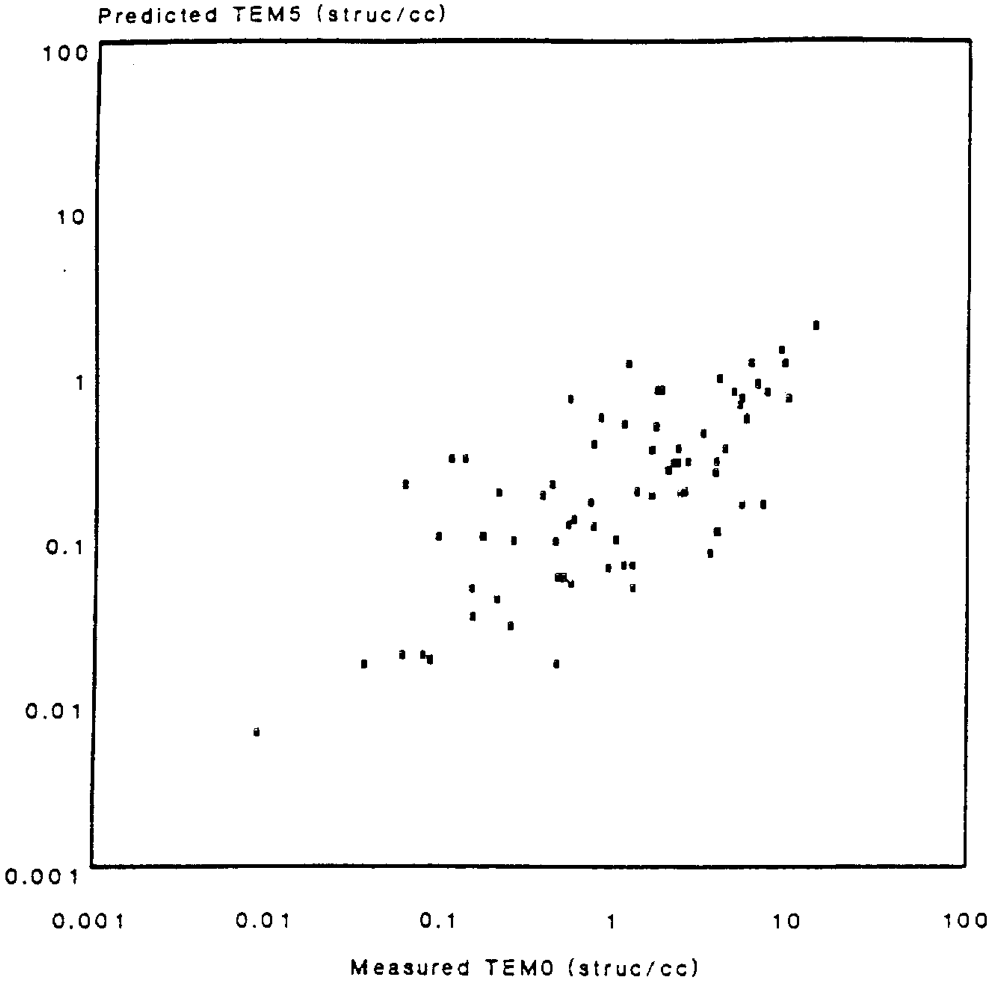

Figure 4-1. EPA Model Performance for Measured TEM0 vs Predicted TEM5 (n=72).

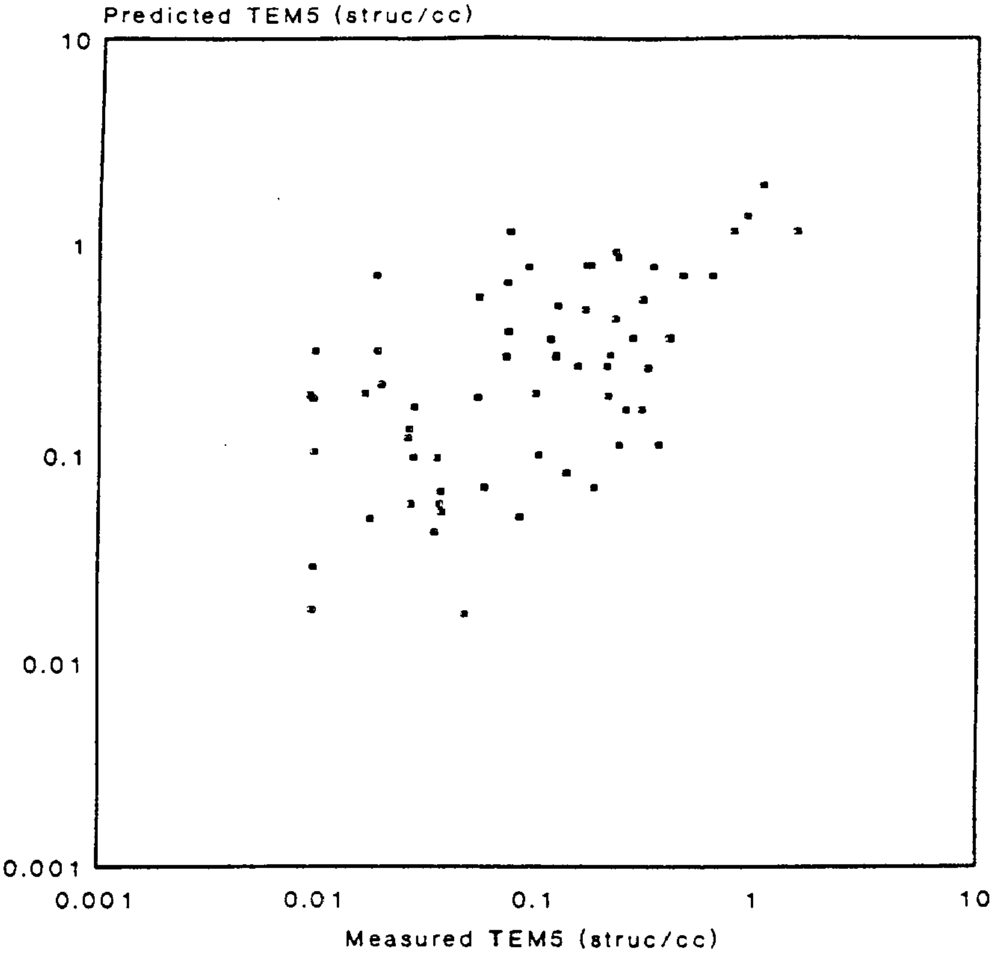

Figure 4-2. EPA Model Performance for Measured TEM5 vs Predicted TEM5 (n=64).

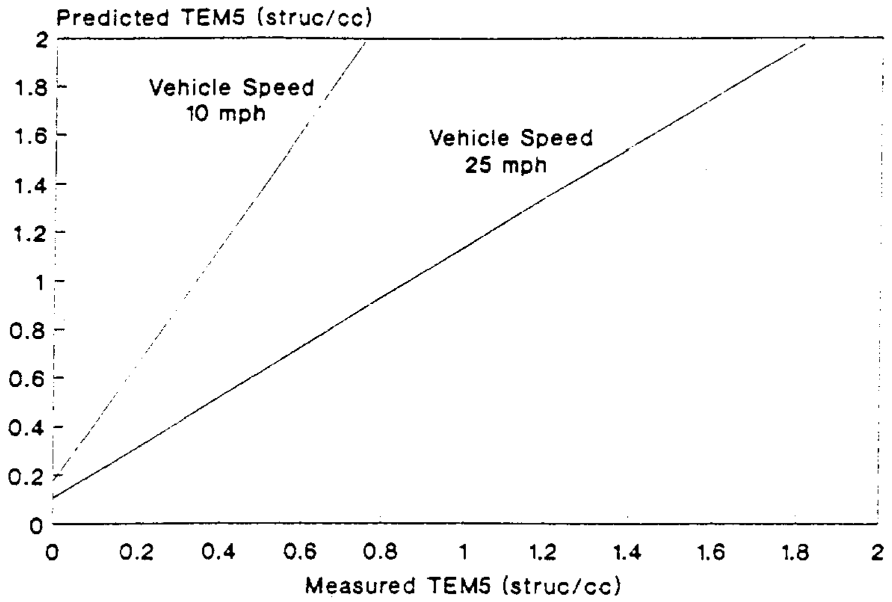

Figure 4-3. EPA Model Performance for Measured TEM5 vs Predicted TEM5 at 10 mph (n=25) and 25 mph (n=39).

Table 4-3. REGRESSION STATISTICS FOR EPA MODEL PREDICTED vs MEASURED ASBESTOS CONCENTRATIONS.

Figure	n	Dependent Variable	Independent Variable	Intercept	Slope	P-Value of Slope	Adjusted r^2
4-1	72	Predicted TEM5	Measured TEM0	0.105	0.097	<0.001	0.55
				—	0.115	<0.001	0.73
4-2	64	Predicted TEM5	Measured TEM5	0.185	0.961	<0.001	0.49
				—	1.275	<0.001	0.67
4-3	25 (10 mph)	Predicted TEM5	Measured TEM5	0.174	2.411	0.003	0.30
				—	3.627	<0.001	0.63
	39 (25 mph)	Predicted TEM5	Measured TEM5	0.108	1.030	<0.001	0.63
				—	1.193	<0.001	0.79

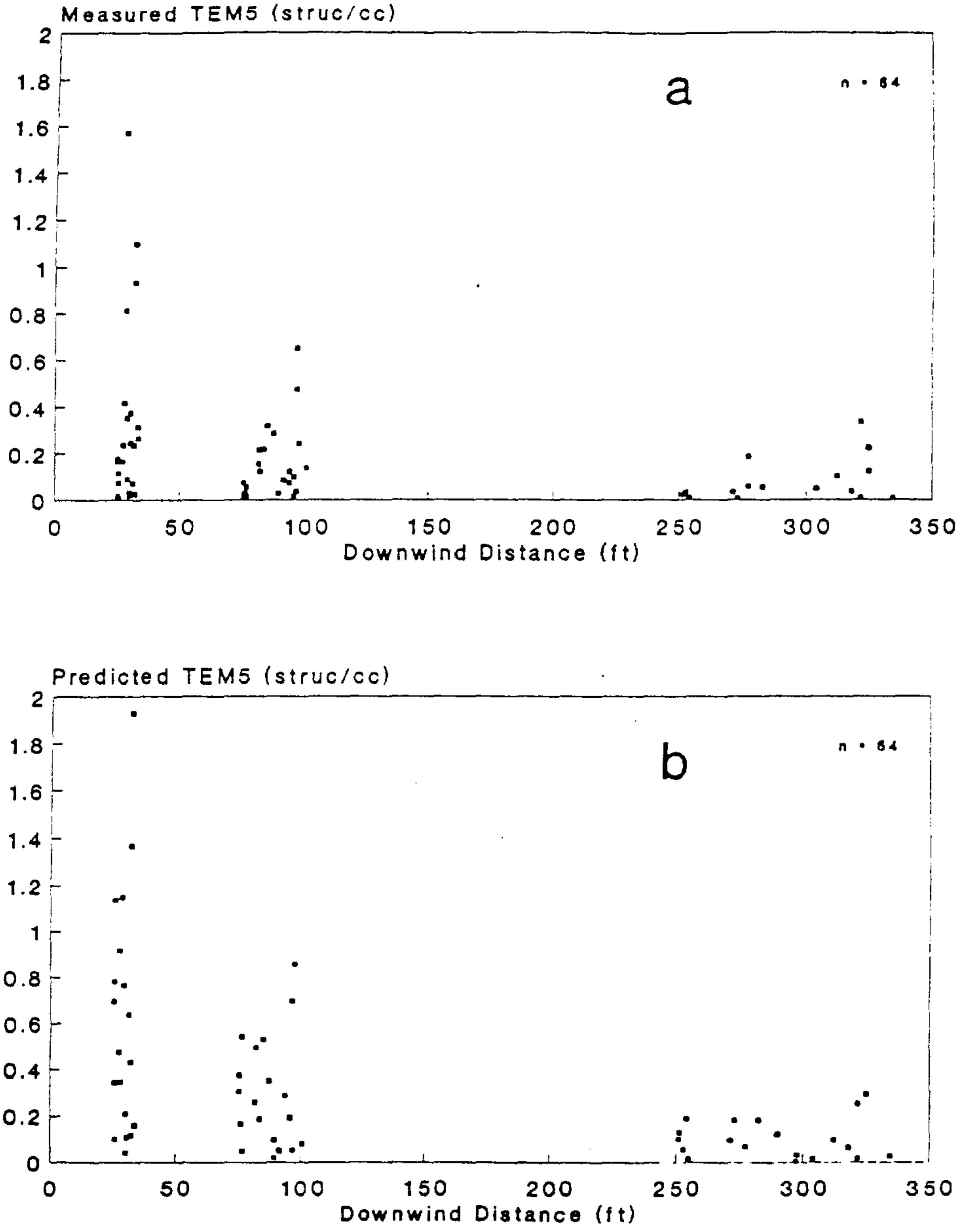

Figure 4-4. EPA Model Performance for Measured (a) vs Predicted (b) Profiles of Downwind Concentrations.

concentrations. The three clusters along the x-axis in each of the profiles represent the three downwind sampler distances of 25 ft., 75 ft., and 250 ft. corrected for wind direction according to Equation 4-1.

4.2 EVALUATION OF THE EPA MODEL STRUCTURE

The present EPA model for assessing asbestos concentrations downwind of an asbestos containing unpaved roadway consists of three model components:

(1) Particulate mass emissions from unpaved road;

(2) Dispersion of emitted asbestos containing particulate matters to downwind receptors; and

(3) Transformation of asbestos containing particulate matter into airborne asbestos fibers.

Using brackets to isolate each of these model components, respectively, the EPA model can be expressed as:

$$A = \left[n\ k\frac{S}{12}\frac{V}{48}\left(\frac{W}{2.7}\right)^{0.7}\left(\frac{WH}{4}\right)^{0.5}\left(\frac{365-p}{365}\right)\right]\left[\frac{2}{(2\pi)^{0.5}\sigma_z U}\right]\left[1.7\ \frac{AC}{100}\ CF\right] \qquad (4\text{-}5)$$

where A = TEM5 airborne asbestos concentration (structures/cc)
k = aerodynamic particle size multiplier
S = silt content of road surface (%)
V = vehicle speed (km/h)
W = vehicle weight (Mg=megagrams)
WH = number of wheels
AC = asbestos content of road surface (%)
n = vehicle frequency (vehicles/s)
σ_z = vertical dispersion parameter (m)
CF = conversion factor (assumes 3×10^{10} structures/g of asbestos)
U = wind speed (m/s)
p = average number of days per year with >0.01 inches of precipitation

The first component of the model is given by the Copeland Emission Factor model, which is said to be the best currently available model for particulate emissions from unpaved roadway. This is confirmed by personal communication with Mel Zeldin of SCAQMD and Drs. Charles Cowherd and Gregory Muleski of the Midwest Research Institute.

The only improvement that can be made on this emission factor equation would be to replace the last precipitation term with soil moisture content. As in the silt content, site-and test-condition specific soil moisture content will be a better parameter for hourly particulate emission rates than the annual number of days with measurable precipitation at a nearby NWS station.

The Gaussian line source dispersion model used in the second component also seems reasonable as evidenced by the similarity of downwind concentration profiles between the measured and model-predicted concentrations (see Figure 4-4).

The third component regarding the transformation of road surface material into airborne asbestos fibers appears to contain several unsubstantiated assumptions. The EPA model assumes that particulate mass emitted from unpaved road increases linearly with increasing vehicle speed as seen in the first component. It is also implicitly assumed that the number of asbestos fibers generated increases linearly with increasing vehicle speed. Although the first assumption seems reasonable, the second assumption does not seem to have been substantiated with any evidence.

4.3 ANALYSIS OF RESIDUALS

The robustness of a prediction model can be examined by plotting the residuals of model-predicted values less measured values against various model parameters. Figures 4-5 through 4-9 show such residual plots against five selected parameters of the EPA model: vehicle speed, traffic volume, asbestos content, moisture content, and silt content. In a residual plot, the model can be said to be robust with respect to a model parameter if residuals scatter randomly around zero at any value of the parameter. If the residual plot exhibits any trend over parameter values, then the model is said to be biased with respect to that parameter.

Figure 4-5 shows that the EPA model tends to overestimate asbestos concentrations at the lower vehicle speed of 10 mph. The EPA model was validated at 30 mph. Therefore, the

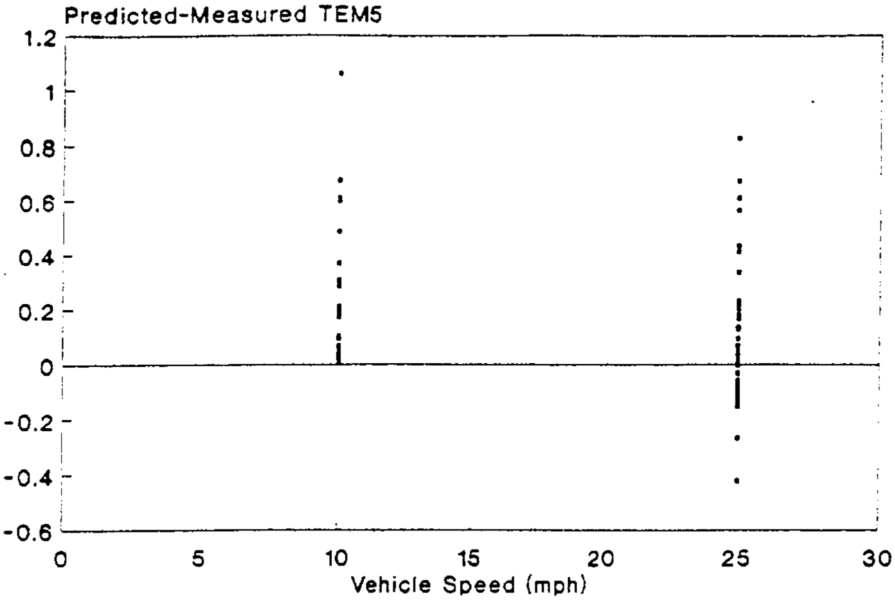

Figure 4-5. Residual Plot against Vehicle Speed.

model performance at 25 mph is quite good as evidenced by the even scatter of residuals around zero. The scatter pattern of residuals in this figure indicates that the number of asbestos structures generated by traffic on unpaved road increase more than linearly with vehicle speed. It can be interpreted that increasing vehicle speed not only increases particulate emissions but also generates more asbestos structures per unit of emitted particulate mass. Therefore, the number of airborne asbestos structures increases more than linearly with increasing vehicle speed. If this interpretation is correct, then the second assumption will turn out to be incorrect. Thus, the EPA model may need to be modified to reflect this fact.

Figure 4-6 shows that the EPA model tends to overestimate ambient asbestos concentrations at the two higher vehicle frequencies, 15 vehicles per hour and 45 vehicles per hour. Figure 3 shows that the model tends to overestimate at higher asbestos contents than 14 percent. Although these tendencies are difficult to explain as to the causes, appropriate correction terms to compensate the tendencies can be introduced to the model if the ARB wants such corrections.

Figures 4-7 and 4-8 show residual plots against bulk asbestos content and road moisture content, respectively. The EPA model, which instead of moisture content uses an annual average precipitation term that was held constant for this analysis, tends to overestimate ambient asbestos concentrations at higher road moisture contents. This is rather counter-intuitive because at the same location, the higher moisture content is expected to result in lower ambient asbestos concentrations. This can be explained by the limited number of sites tested, and the fact that the highest moisture contents happened to occur at the site with the highest bulk asbestos content (i.e., Site 3, see Table 3-4).

Figure 4-9 shows that the EPA model tends to overestimate ambient asbestos concentrations at the higher silt contents around 7.5 percent. The model assumes that asbestos concentrations increase linearly with increasing silt content of the road surface material. However, as with moisture content, silt content may have been coincidentally correlated with other road surface variables at the 4 sites, thus obscuring any direct relationship.

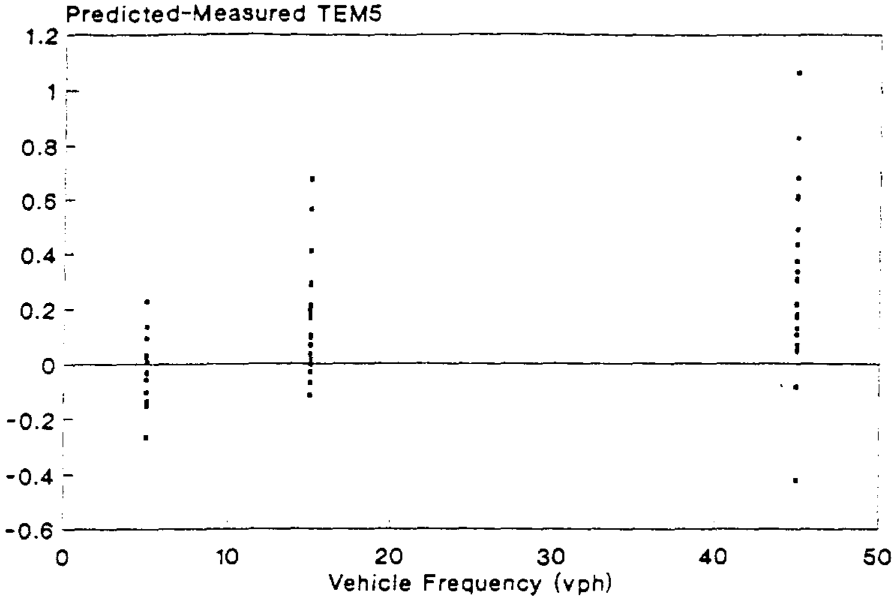

Figure 4-6. Residual Plot against Traffic Volume.

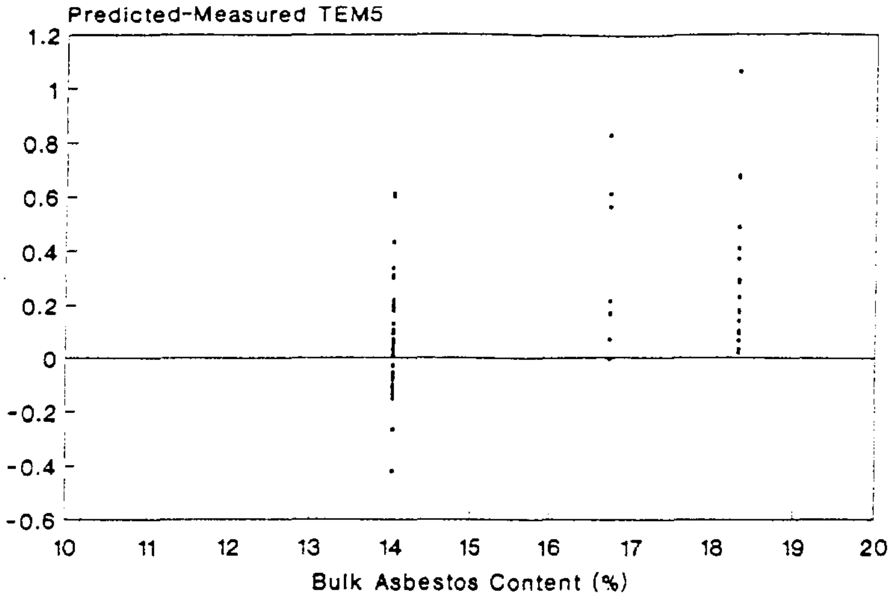

Figure 4-7. Residual Plot against Bulk Asbestos Content.

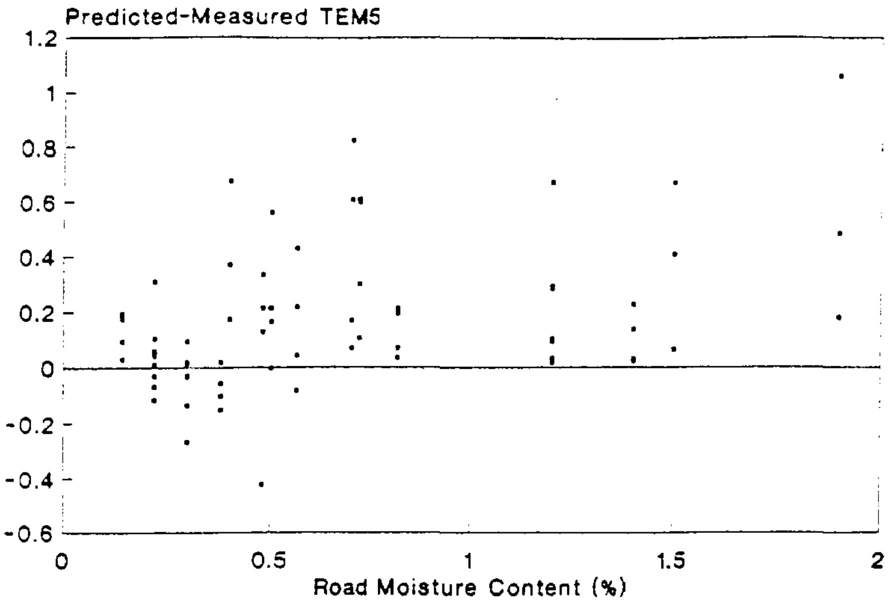

Figure 4-8. Residual Plot against Road Moisture Content.

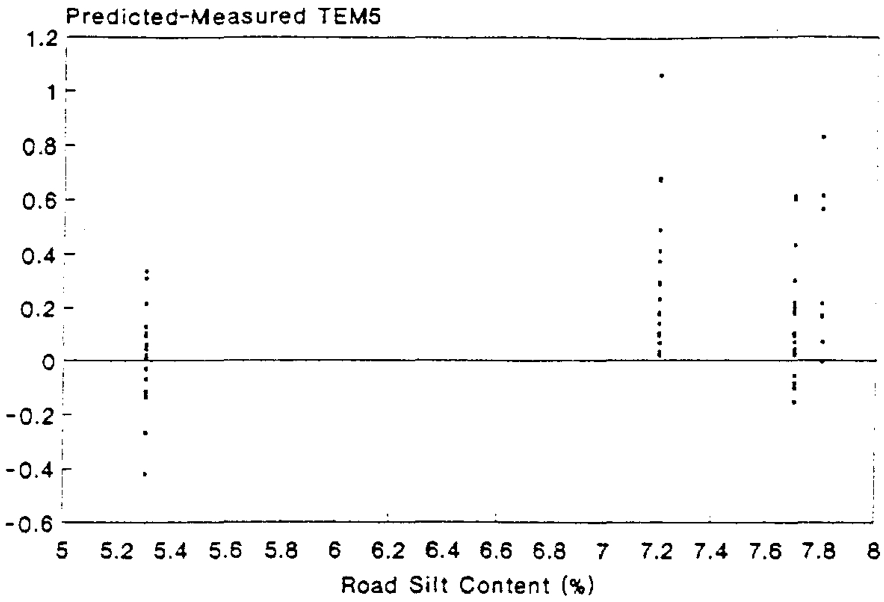

Figure 4-9. Residual Plot against Road Silt Content.

5.0 DEVELOPMENT OF MODIFIED ROAD MODEL

5.1 OBJECTIVES FOR MODEL IMPROVEMENT

The EPA model given by Equation (4-2) contains both a climatological parameter -- precipitation days -- and short temporal parameters such as the atmospheric stability and the dispersion coefficient. Although other model parameters such as vehicle speed, vehicle frequency, and wind speed can be either long-term (e.g., a year) averages or short-term (e.g., 1-hour) averages, the number of days per year with precipitation is by definition a long-term average. On the other hand, the dispersion coefficient and atmospheric stability are meaningful only for a time period of a few minutes to a few hours.

Because of the mixture of a climatological parameter and short temporal parameters in the same equation, the EPA model seems somewhat illogical in its current form. The model appears to be a product of a short-term model and an adjustment term for calculating a long-term average of the concentrations predicted by the short-term model. The precipitation days term of Equation (4-2) is indeed the adjustment term for long-term average concentrations under the following two assumptions;

(1) Road dust emissions arise only on days with no measurable precipitation; and
(2) The dispersion and traffic conditions remain the same over the period of interest.

The first assumption seems reasonable whereas the second assumption is more uncertain. Dust from the road will reach the receptor only while the wind direction has a component toward the receptor. Under most climatological conditions, this occurs less than 100 percent of the time.

As a predictive model, it should also provide the user an option of estimating short-term averages. For this purpose, the precipitation days term of the EPA model was replaced with a new model parameter for road surface moisture content that has proved to be useful for explaining an inverse relationship between dust generation and moisture content observed in the field experiments.

As described in the preceding section, the EPA model exhibits biases with respect to some model parameters. Thus it was a goal to reduce these biases by determining and applying a proper correction term to the EPA model. In addition, two additional features were considered important: a module to account for the effect of a finite road segment (instead of an infinite line source) on downwind concentrations; and a module to estimate short-term concentrations as well as long-term average concentrations.

5.2 DEVELOPMENT OF SHORT-TERM MODEL

To reduce the biases found in the EPA model evaluation (Section 4.0), a correction term, G, is explored in this section. For each of the 64 data points used in the model evaluation, G was calculated as:

$$G = \text{(Measured TEM5)/(Predicted TEM5)} \qquad (5\text{-}1)$$

where Measured TEM5 is the measured airborne asbestos concentration for structures ≥ 5 µm and Predicted TEM5 is the airborne asbestos concentration predicted by the EPA model without the term for precipitation days (p). A series of multiple linear regressions were then calculated according to the equation:

$$\log G = b_1 \log X_1 + b_2 \log X_2 + ... + b_n \log X_n + \log C \qquad (5\text{-}2)$$

where b is the slope of the regression, X represents measured model parameters, and C is a constant. The regression was performed on several different combinations of variables such as vehicle frequency, vehicle speed, silt content, etc. The most plausible result was obtained from the use of vehicle speed and moisture content, as:

$$\log G = \log V - 0.6 \log M - 5.5 \qquad (5\text{-}3)$$

where V is vehicle speed and M is percent moisture content of the road surface. This equation explained about 48% of the variance in log G ($p < 0.001$) and was found to reduce 76% of the variance of the model prediction errors on the 64 data points. Thus an improved VRC model is written as:

$$\begin{aligned} \text{[VRC MODEL]} &= \text{[EPA MODEL]} \times G && (5\text{-}4)\\ &= \text{[EPA MODEL]} \times 0.012 \times VM^{-0.6} && (5\text{-}5) \end{aligned}$$

or:

$$A - 1.7\ k\ \frac{2}{(2\pi)^{0.5}}\ \frac{S}{12}\ \frac{V^2}{48} \left(\frac{W}{2.7}\right)^{0.7} \left(\frac{WH}{4}\right)^{0.5} \frac{AC}{100}\ \frac{n}{\sigma_z}\ \frac{CF}{U}\ \frac{0.012}{M^{0.6}} \qquad (5\text{-}6)$$

This equation represents the short-term model for predicting hourly average concentrations for cases where some site-specific data on asbestos, silt, and moisture contents and on local wind conditions are available.

Figure 5-1 shows a scatter plot of the concentrations predicted by the VRC model vs measured concentrations. Although substantial scatter is still evident, it represents an improvement over the EPA model performance as shown in Figure 4-2. The VRC model explains 81% of the variance in the measured concentrations, compared to 67% explained by the EPA model.

5.2.1 DEFAULT VALUES

The computer code of the VRC model is designed to assign default values for all unspecified model parameters. The purpose of assigning default values is twofold:

(1) To provide a basis for sensitivity analyses and demonstration of the model.
(2) To provide model users with reference values.

In view of these purposes, default values should be selected to be as representative as possible of situations in which the model is likely to be used. Defaults were selected as follows:

Stability Class: Stability class is an alphabetic categorical variable with a lookup table (Table 4-2) to calculate a dispersion parameter, σ_z. Though the neutral class D is used as a default in the EPA model, and indeed is the most likely typical stability class in the long term, it is not considered representative of atmospheric stability during peak traffic hours. Thus stability class B was selected as the default because it represents an intermediate stability during daylight conditions.

k-factor: In accordance with AP-42, the default value for k is set to 0.36, which is the aerodynamic particle-size multiplier for particles ≤ 10 μm.

Silt Content: The default silt content was set to 7%, which was typical of the 4 field experiment sites, all of which were moderately worn roadways.

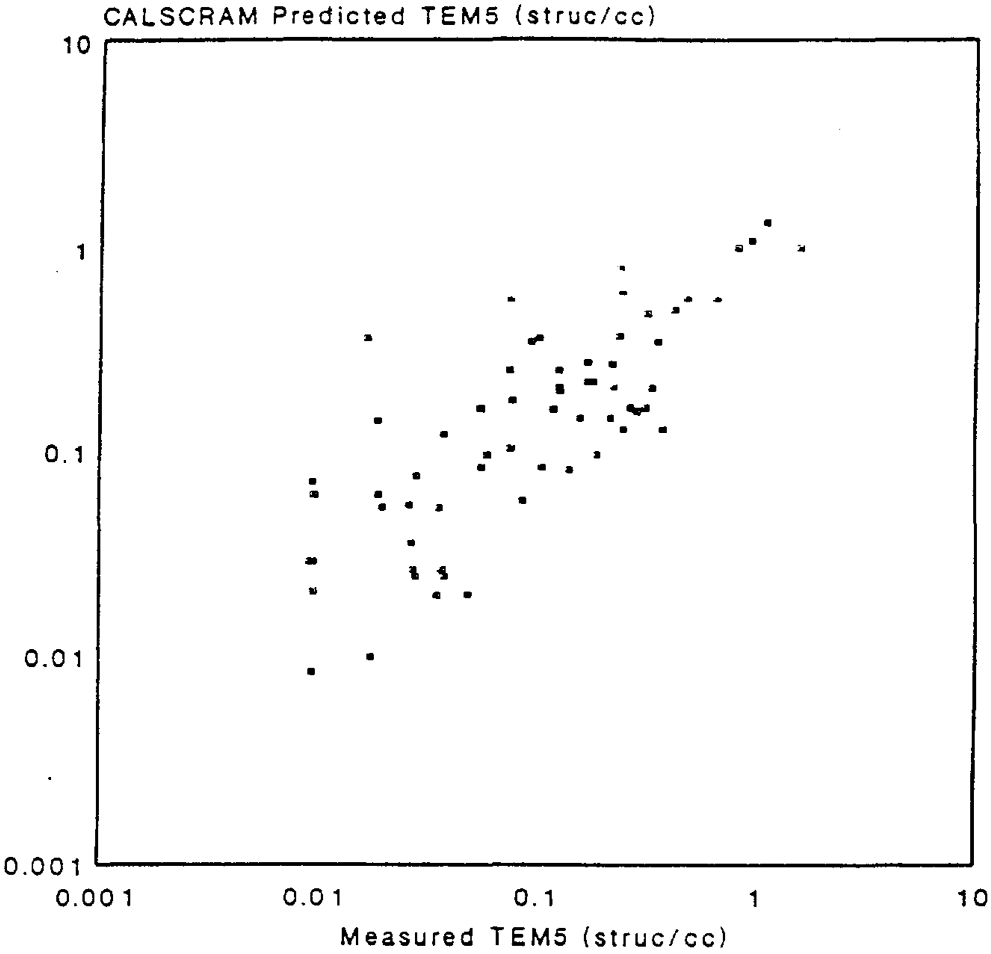

Figure 5-1. VRC Model Performance for Measured TEM5 vs Predicted TEM5 (n=64).

Vehicle Speed: The default vehicle speed was set to 25 mph, for reasons discussed in Section 2.2.3.

Vehicle Weight: The default vehicle weight was set to 1.8 tons, which is typical of a light truck or van.

Number of Wheels: The default number of wheels was set to 4.

Vehicle Frequency: The default vehicle frequency was set to 5 veh/h.

Asbestos Content: The default asbestos content was set to 10%, which is lower than typical asbestos contents in the Oakdale region where the field experiments were conducted, but may be more representative of serpentine-covered roads statewide.

H: The default value for H, the initial dispersion of the vehicle wake, was set to 1 m, which is roughly 50% of the height of a light truck or van.

Wind Speed: The default wind speed is set to 3 m/s, which is typical of wind speeds observed in the Oakdale area during the field experiments (mean wind speed for Stockton is 3.3 m/s; Fresno 2.8 m/s).

Moisture Content: The default value for road moisture content was set to 1%.

5.2.2 SENSITIVITY ANALYSIS

To determine model sensitivity to changes in model parameters, each input parameter was first decreased from default setting by 10% and then increased by 10% while all other input parameters were held at default levels. The mean deviation of the two resultant model outputs was then divided by the model output at default settings. Model parameters are ranked in Table 5-1 in descending order of the model's sensitivity to an equal percent change in these parameters. Sensitivity of the EPA model is shown for comparison. The model is most sensitive to changes in vehicle speed and least sensitive to changes in H. Since stability class is an ordinal variable and thus cannot be changed by a percentage as with other parameters, sensitivity of the model to changes in stability class as a function of downwind distance was separately computed (see Figure 5-2).

Table 5-1. MODEL SENSITIVITY

Parameter	Default Value	Sensitivity[a]	
		EPA Model	VRC Model
V	25 mph	10%	20%
k	0.36	10%	10%
S	7%	10%	10%
n	5 vph	10%	10%
AC	10%	10%	10%
U	3 m/s	10%	10%
d[b]	50 ft	7.3%	7.3%
W	1.8 tons	7%	7%
M[c]	1%	na	6%
WH	4	5%	5%
H[b]	1 m	2%	2%

[a] Sensitivity defined as the average percent change in output given a 10% increase or decrease in the value of the parameter at default conditions.

[b] Parameter sensitivity dependent on downwind distance, 50 ft in this analysis.

[c] Moisture content (M) is not included as a parameter in the EPA model.

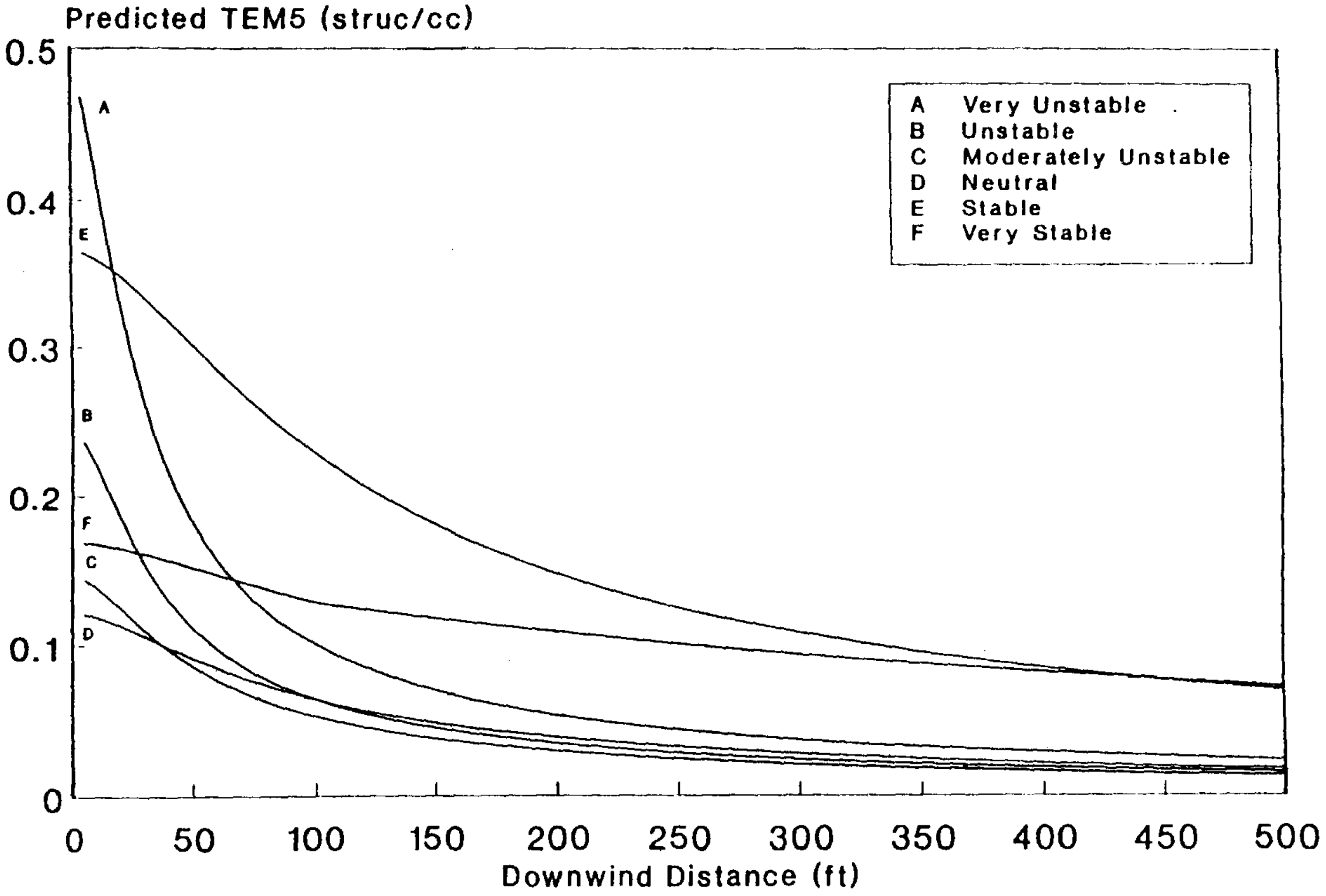

Figure 5-2. Asbestos Concentrations as a Function of Downwind Distance for Each Stability Class.

5.2.3 SHORT ROAD SEGMENTS

The EPA model is based on a line source dispersion equation given by Turner (1970). The equation assumes that the line source is infinite. This assumption has little impact on model predictions for longer road segments. However, in cases where the length of the road segment is less than about the distance from the road to the receptor, this will cause progressive overestimation with increasing distance from the road.

Turner (1970) also provides a correction term needed for short road segments which can be expressed as:

$$\frac{1}{\sqrt{2\pi}} \int_{p_1}^{p_2} e^{-p^2}\, dp \qquad (5\text{-}7)$$

where $p = y/\sigma_z$ and y is the lateral distance along the roadway. The values p_1 and p_2 are given for y = -L/2 and y = +L/2 where L is the length of the road segment. It is assumed that the receptor is directly downwind of the midpoint of the road segment, L.

Table 5-2 shows the effects of a finite road segment on downwind concentrations under various stability classes. The effects are most pronounced under A stability and the least under D stability.

5.3 DEVELOPMENT OF LONG-TERM MODEL

An easy-to-use long-term model was devised by introducing two adjustment terms to the VRC short-term model equation: climatological wind term and precipitation days term. The precipitation days term is the same as that of the EPA model, namely, (365-p)/365, where p is the number of days with 0.01 inches or more of precipitation.

The climatological wind term is introduced to account for receptor concentrations brought about by the wind blowing from several different directions over a year or other long period. Assuming that the emission rate remains the same over the period, a long-term average receptor concentration from the emission source is given by:

Table 5-2. EFFECT OF FINITE ROAD SEGMENT ON DOWNWIND CONCENTRATIONS.

Road Length (ft)	Downwind Distance (ft)	Downwind Concentration under Stability Class (struc/cc)			
		A	B	D	F
∞	50	.0636	.0519	.0424	.1517
∞	100	.0351	.0298	.0298	.1282
∞	500	.0082	.0072	.0082	.0504
200	50	.0635	.0518	.0424	.1515
200	100	.0350	.0297	.0297	.1280
200	500	.0069	.0068	.0082	.0504
50	50	.0627	.0514	.0424	.1506
50	100	.0309	.0281	.0296	.1280
50	500	.0023	.0027	.0059	.0487

Note: Wind speed set as: A - 2 m/s, B - 3 m/s, D - 6 m/s, F - 2 m/s

$$\frac{2Q}{(2\pi)^{0.5}} \sum_{i=1}^{8} \frac{f_i}{\sigma_{zi} U_i} \tag{5-8}$$

where Q is the emission rate, f_i is the fraction of the time that wind blows from the i-th sector of the wind rose for the area, U_i is the average wind speed of the i-th sector wind, and i (=1 to 8) is one of the 16 sectors of 22.5 degrees in the wind rose which has at least some component blowing from the roadway to the receptor. The dispersion coefficient σ_{zi} is computed in the same manner as for the short-term model using the mid-direction of each sector wind. The value for downwind distance used to calculate σ_z is given by:

$$x_i = \frac{x}{\cos(DEV_i)} \tag{5-9}$$

where x is the receptor distance from the roadway, x_i is the downwind distance corrected for wind direction, and DEV_i is the deviation of the mid-direction of the i-th sector wind from the perpendicular path of the roadway (see Eq. 4-1).

The long-term model is therefore expressed as:

$$A = 1.7\ kn\ \frac{S}{12}\ \frac{V^2}{48} \left(\frac{W}{2.7}\right)^{0.7} \left(\frac{WH}{4}\right)^{0.5} \frac{AC}{100}\ CF \frac{0.012}{M^{0.6}}\ \frac{15}{24}\ \frac{365-p}{365}\ \frac{2}{(2\pi)^{0.5}} \sum_{i=1}^{8} \frac{f_i}{\sigma_{zi} U_i} \tag{5-10}$$

5.4 DEVELOPMENT OF COMPUTER PROGRAM

A computer program called CALSCRAM (California Serpentine-Covered Roadway Asbestos Model) was written and compiled for IBM PC[*] and compatible computers in Microsoft QuickBasic[**] for use as an efficient means of processing model calculations. The program allows users to either manually enter model inputs or, for users needing to process large numbers of cases, use comma-delimited ASCII data files for model inputs. A user's manual for the program is provided in Appendix C.

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[*] IBM PC is a registered trademark of International Business Machines Corporation.

[**] QuickBasic is a registered trademark of Microsoft Corporation.

6.0 REFERENCES

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Cowherd, C., and C. Guenther (1976) "Development of a methodology and emission inventory for fugitive dust for the regional air pollution study." Prepared for U.S. Environmental Protection Agency, Office of Air and Waste Management, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina.

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APPENDIX A

Collocated Sampler Results

Table A-1. COLLOCATED SAMPLER RESULTS FOR SITES 1 AND 2.

Date	Run	Time Start	Veh. Speed (mph)	Veh. Freq. (vph)	Sampler Dist. (ft)	Sampler Height (m)	PCM5 (f/cc)	TEM5 (struc/cc)	TEM0 (struc/cc)
Site 1									
8/19/91	3	17:40	25	15	75	1.5	0.02	0.02	0.94
							0.01	0.10	2.56
8/20/91	5	14:28	25	5	25	1.5	0.05	0.32	7.25
							0.06	0.27	5.47
8/20/91	6	17:08	25	45	75	1.5	0.08	0.48	5.41
							0.07	0.65	10.04
8/23/91	7	12:35	10	15	25	1.5	0.01	0.02	0.44
							0.01	0.00	0.06
8/23/91		14:00	10	45	25	1.5	0.02	0.18	1.87
							0.01	0.17	1.76
Site 2									
8/21/91	2	14:40	25	45	25	1.5	0.09	1.57	9.57
							0.10	0.81	6.15
8/21/91	3	15:52	10	45	75	1.5	0.02	0.15	2.07
							0.01	0.22	2.04
8/21/91	4	17:10	25	15	250	1.5	0.01	0.06	1.31
							0.01	0.19	1.17
8/22/91	5	13:05	10	15	50up	1.5	0.01	0.00	0.01
							0.01	0.00	0.01
8/22/91	6	14:35	25	5	25	1.5	0.03	0.25	3.90
							0.02	0.38	3.99
8/22/91	7	15:55	10	5	75	1.5	0.01	0.00	0.08
							0.01	0.00	0.06

Table A-2. COLLOCATED SAMPLER RESULTS FOR SITES 3 AND 4.

Date	Run	Time Start	Veh. Speed (mph)	Veh. Freq. (vph)	Sampler Dist. (ft)	Sampler Height (m)	PCM5 (f/cc)	TEM5 (struc/cc)	TEM0 (struc/cc)
Site 3									
9/12/91	2	14:50	10	45	50up	1.5	0.01	0.00	0.03
							0.01	0.00	0.05
9/12/91	3	15:52	25	15	25	1.5	0.05	0.09	8.32
							0.05	0.35	5.33
9/13/91	4	12:12	10	15	75	1.5	0.01	0.02	0.11
							0.01	0.01	0.14
9/13/91	5	13:21	25	5	250	1.5	0.01	0.03	0.47
							0.01	0.04	0.51
9/13/91	6	14:28	10	5	25	3.0	0.01	0.00	0.05
							0.01	0.00	0.04
Site 4									
9/14/91	2	13:47	25	45	250	1.5	0.02	0.22	3.86
							0.03	0.12	2.66
9/14/92	3	15:45	25	15	75	1.5	0.03	0.12	2.34
							0.03	0.07	2.18

APPENDIX B

Current Airborne Asbestos Exposure Standards

The relationship between exposure to ambient levels of asbestos and health risk is a subject that includes many controversial and unresolved issues, such as the importance of differentiating among fiber types and sizes, the applicability of the original health data used to calculate cancer risks, and the extrapolation of high occupational exposures to low-exposure situatations. For further background on these issues, we strongly encourage the reader to consult the technical literature on asbestos-related health issues. However, for convenient reference, the following current exposure standards are presented:

Occupational Safety and Health Administration (OSHA)

Permissible airborne exposure limit for workers: 0.2 f/cc by PCM for fibers ≥ 5 µm, 8-hour time-weighted average.

Action level for asbestos in the workplace: 0.1 f/cc by PCM for fibers ≥ 5 µm, 8-hour time-weighted average.

National Institute for Occupational Health and Safety (NIOSH)

Standard for chrysotile asbestos: 0.1 f/cc by PCM for fibers ≥ 5 µm, 8-hour time-weighted average.

APPENDIX C

User's Manual for the CALSCRAM Computer Program

1.0 INTRODUCTION

The CALSCRAM program is intended to provide a cost-effective means for making preliminary estimates of airborne asbestos concentrations at receptor sites downwind of asbestos-containing serpentine-covered unpaved roads. At minimum, it requires the user to know the following information:

1. The bulk asbestos content of the road surface material, preferably as measured by ARB Test Method 435.
2. The silt content of the road surface material.
3. Typical traffic volume and patterns.
4. Typical wind speed and direction, and either typical number of days per year with 0.01 inches or more of rainfall, or the moisture content of the road surface material.
5. The downwind distance(s) of the receptor(s) of interest.

The user should also be familiar with each of the input parameters as listed in Table **1**. Default values are provided by the program as a reference for users. Most input values are requested in English units (feet, miles, tons). These are internally converted to metric units by the program.

Model output is given as TEM5 asbestos concentration, which is defined as asbestos structures ≥5 µm in length as measured by transmission electron microscopy. The units are structures per cubic centimeter (struc/cc).

2.0 SETUP

The model was created in Microsoft QuickBasic and is designed to run on IBM PC or compatible computers operating under DOS 3.1 or later version. It is provided on a 3.5 inch floppy disk. It can be executed by either typing b:\CALSCRAM or by creating a subdirectory on a hard disk, copying the contents of the floppy disk to that directory, and typing CALSCRAM at the appropriate DOS prompt. Users should refer to a DOS reference guide if they are unfamiliar with the appropriate procedures.

3.0 EXECUTING THE PROGRAM

After an introductory screen, you are provided the option to quit the program or to continue with model implementation. There are two options for specifying input parameters: for on-screen input select 1; for file input select 2. If you are a first-time user and have not prepared an ASCII input file, select 1.

3.1 ON-SCREEN INPUT

The on-screen input option allows direct modification of input values while providing instantaneous model output. The output during manual input can be either case-specific (i.e., concentration averaged over a period of less than 3 hours) or long-term average concentration. The screen is initially set up for calculation of case-specific concentrations.

To modify input values or to activate model features, type the number associated with the parameter of interest at the prompt:

```
Select parameter to modify?
```

and hit enter. You will then be asked to enter a new value for the parameter. An explanation of each input parameter is provided below and in Table 1.

1. **Site ID:** The Site ID, which is optional, is user specified and does not affect estimates of airborne concentrations. It may consist of up to 8 characters.

2. **Stability Class:** The stability class (A, B, C, D, E, or F) is used to characterize atmospheric conditions that affect dispersion. Though the neutral class D is used as a default in the EPA model, and indeed is the most likely typical stability class in the long term, it is not considered representative of atmospheric stability during peak traffic hours. Thus stability class B was selected as the default because it represents an intermediate stability during daylight conditions.

3. **k-factor:** In accordance with AP-42, the default value for k is set to 0.36, which is the aerodynamic particle-size multiplier for particles ≤ 10 μm.

4. **Silt Content:** Silt content is the percent of the road surface material by dry weight that will pass a No. 200 sieve per ASTM Method D1140. The default silt content is set to 7%, which was typical of the 4 field experiment sites, all of which were moderately worn roadways.

5. **Vehicle Speed:** Vehicle speed is the average speed in miles per hour of all vehicles passing the subject road segment. The default vehicle speed is set to 25 mph.

Table 1. INPUT PARAMETERS FOR THE MODEL.

Input Parameter	Units	Default Value	Explanation
Site ID	none	none	User specified, up to 8 characters.
Stability Class	none	B	Atmospheric conditions (see Table #-#).
k	none	0.36	Particle size multiplier, as given by AP-42.
Silt Content	%	7	Percent of road surface material (by weight) passing a 200 Tyler mesh, measured by ASTM Method D1140
Vehicle Speed	mi/h	25	Average speed of vehicles traveling on subject road.
Vehicle Weight	tons	1.8	Average weight of vehicles traveling on subject road.
Number of Wheels	none	4	Average number of wheels of vehicles traveling on subject road.
Precipitation Days	days/yr	50	Number of days per year with 0.01 inches or more of precipitation. Sample values for California: Fresno 30, Red Bluff 70, Sacramento 57, Stockton 52.
Vehicle Frequency	veh/h	5	Average number of vehicle passes across subject road per hour.
Asbestos Content	%	10	Bulk asbestos content of road surface material, measured by ARB Test Method 435.
H	m	1	Initial vertical dispersion of the vehicle wake. At typical speeds, it is recommended that H be set to 50% of the average vehicle height.
Wind Speed	m/s	3	Average speed of wind blowing from the subject road toward the receptor.
Moisture Content	%	1	Percent of road surface material (by weight) that is moisture, measured by ASTM Method D2216.
Downwind Distance	ft	50	Distance from the road to the receptor, measured parallel to the prevailing wind direction.

6. **Vehicle Weight:** Vehicle weight is the average weight in tons of all vehicles passing the subject road segment. The default vehicle weight is set to 1.8 tons, which is typical of a light truck or van.

7. **Number of Wheels:** This is the average number of wheels of vehicles passing the subject road segment. The default number of wheels is set to 4.

8. **Vehicle Frequency:** The vehicle frequency is the average number of vehicle passes per hour over the subject road segment during the entire period of interest. The default vehicle frequency is set to 5 veh/h.

9. **Asbestos Content:** The asbestos content is the percent bulk asbestos content of the road surface material as determined by ARB Test Method 435. The default asbestos content is set to 10%. Typical asbestos contents for road surfaces consisting of mined serpentine rock in California are 5% to 15%.

10. H: H is the initial dispersion height of the vehicle wake. The default value is set to 1 m, which is roughly 50% of the height of a light truck or van.

11. **Wind Speed:** Wind speed is the average wind speed in meters per second. The default wind speed is set to 3 m/s, which is typical of wind speeds in much of California (some mean wind speeds for California: Bakersfield 2.9, Fresno 2.8, Red Bluff 3.9, Sacramento 3.7, and Stockton 3.3). This parameter becomes inactive if a long-term average is selected.

12. **Moisture Content:** Moisture content is the percent of the road surface material by dry weight that is moisture according to ASTM Method D2216. The default value for road moisture content is set to 1%. This parameter becomes inactive if a long-term average is selected.

13. **Downwind Distance.** Downwind distance refers to the distance in feet from the center of the roadway to the receptor. The downwind distance of the receptor is measured at its closest point to the roadway. The model is recommended to be used to determine case-specific concentrations only if the wind direction is within 45° of perpendicular to the roadway. If the wind is not perpendicular, the downwind distance must be adjusted by dividing the perpendicular distance by the cosine of the wind direction's deviation from perpendicular, thus giving the net travel distance of the induced dust from the road to the receptor. If you are determining a long-term average, the downwind distance is always measured along an axis perpendicular to the road orientation. The model then internally calculates the adjusted travel distance for each of the 16 wind sectors.

14. **Short Road Segment.** Since the basic model is based on an "infinite line source" assumption, it may overestimate concentrations for road segments that are less than about 1000 ft. Generally, the infinite line source assumption is reasonable if the receptor is closer to the road segment than the length of the straight road segment. To correct for a short road segment, enter "14" at the select parameter prompt. You will be asked to enter the length of the subject road segment. To return to a long road segment (i.e., infinite line source assumption), hit enter at this prompt.

15. **Long Term Average.** Long-term averages (e.g., annual averages) will generally be lower than short-term averages because of variable wind directions and precipitation. To estimate a long-term average, enter "15" at the select parameter prompt. Two selections will become available for modification: "Precipitation Days" and "Wind Sectors". These replace "Moisture Content" and "Wind Speed", respectively, which both become inactive. When estimating long-term averages, be sure that the vehicle frequency and other parameters are representative of the entire time frame. To return to a case-specific estimate, enter "15" at the select parameter prompt.

16. **Precipitation Days:** The precipitation days selection is activated for long-term averages only. Precipitation days are the number of days per year with 0.01 inches or more of precipitation. The default value for precipitation days is set to 50 (some mean precipitation days for California: Bakersfield 36, Fresno 34, Mount Shasta 90, Red Bluff 70, Sacramento 57, and Stockton 52).

17. **Wind Sectors:** The wind sectors option is activated for long-term averages only. Wind rose data will increase the accuracy of long term averages because of changes in wind speed and direction over time. The information required is the percent of time the wind direction falls under each of 16 wind rose sectors, the average wind speed for each sector, the road orientation, and the direction, perpendicular to the road orientation, of the receptor (receptor-normal direction). The first time you view the wind sector screen, the time percentages are filled with default values approximating the wind rose percents from Fresno. The wind speed is set to the default speed of 3 m/s. The road orientation is set to 90°, which is an east-west trending roadway, and receptor-normal direction is 180°, which means the receptor is on the south side of the roadway.

    By entering "17" at the select parameter prompt, you will access the wind sector screen. You will first be asked whether you wish make modifications to percent of time, wind speed, or road orientation (P, W, or R). At this prompt you can also return to the main screen by hitting enter. If you select P or W, you will be asked to first enter the sector for modification and then the new value. If you select R you will first be asked to enter the road orientation and the receptor-normal direction.

18. **Restore Defaults:** The restore defaults option allows you to delete all changes made during the on-screen input option and return all parameters to their default values. Default values for input parameters are listed in Table 1.

19. **Save Settings:** This option saves all current model inputs to a file. Note that only one test case can be saved in each file.

20. **Retrieve Settings:** This option retrieves from a file model inputs from previously saved test cases.

21. **Print:** This will produce a printout of the current case, including all model inputs and the output.

22. **Help:** Select this option for explanations of any of the input parameters or features in selections 1 to 21.

3.2 FILE INPUT

The file input option allows you to use an input file in comma-delimited ASCII format. The output can be sent to an output file, to a printer, or to the screen. Input files, which should be created within your database or spreadsheet software, must have the following comma-delimited fields:

1. Site ID	alphanumeric (up to 8 characters)
2. Stability Class	alphanumeric (A, B, C, D, E, or F)
3. k	numeric
4. Silt Content	numeric (%)
5. Vehicle Speed	numeric (mi/h)
6. Vehicle Weight	numeric (tons)
7. Number of Wheels	numeric
8. Vehicle Frequency	numeric (veh/h)
9. Asbestos Content	numeric (%)
10. H	numeric (m)
11. Wind Speed	numeric (mi/h)
12. Moisture Content	numeric (%)
13. Downwind Distance	numeric (ft)

The output during file input is "case-specific", which means that it is not averaged over 24 hours or annually. If the file input option is to be used to calculate long-term exposures, you must input typical or average values for each input parameter or, preferably, do enough model runs to represent the temporal variation in traffic and weather at the site and use the output to calculate a concentration averaged over the desired time scale.

Output can be sent to the screen, a printer, or a file by selecting S, P, or F at the output prompt.

Appendix H

Summary Data from Unpaved Road Survey

Table H-1
Survey Results for USFS and BLM

Governmental Agency	Estimated Miles of Unpaved Serpentine Roads	Policy on Use of Serpentine Materials
U.S. Forest Service		
Six Rivers	90	No Policy
Tahoe	0	Will Not Use
Mendocino	0	Will Not Use
Stanislaus	10	Will Test[1]
Lassen	0	Will Not Use
El Dorado	0	Will Not Use
Klamath	150	Will Test[1]
Modoc	0	No Policy
Sequoia	0	No Policy
Plumas	10-20	Will Test
Cleveland	0	Will Not Use
Inyo	0	No Policy
Total	**250-260[2]**	
Bureau of Land Management		
Hollister	100	Use in-situ serpentine material. If hauled in, will use non-serpentine materials
Folsom	Unknown	Will Not Use
Bishop	Unknown	No Policy
Surprise	0	Will Not Use
Alturas	0	Will Not Use
Arcata	12	Will Not Use
Barstow	0	Will Not Use
Needles	0	Will Not Use
Palm Springs	0	Will Not Use
Eagle Lake	0	No Policy
El Centro	0	No Policy
Total	**112**	

[1] Will test material in accordance with ARB Test Method 435.

[2] Likely an underestimate since data was not provided by the Shasta-Trinity, Sierra, and Los Padres regional offices.

Table H-2
Survey Results For County Public Works Departments

County	Miles of Unpaved Serpentine Roads	Policy on Use of Serpentine Materials
El Dorado	4	No Policy
Fresno	0	No Policy
Glenn	Unknown	No Policy
Humbolt	16	No Policy
Imperial	0	No Policy
Inyo	0	No Policy
Kern	0	No Policy
Kings	0	No Policy
Lake	Unknown	No Policy
Lassen	0	No Policy
Los Angeles	0	Will Not Use
Madera	0	Will Not Use
Marin	0	No Policy
Mariposa	0	Will Not Use
Mendocino	Unknown	No Policy
Merced	0	No Policy
Modoc	Unknown	No Policy
Mono	0	No Policy
Napa	11	No Policy
Nevada	Unknown	No Policy
Orange	0	No Policy
Placer	8-10	No Policy
Riverside	0	No Policy
San Benito	0	No Policy
San Bernardino	0	No Policy
San Diego	0	No Policy
San Joaquin	0	No Policy
San Luis Obispo	0	No Policy
San Mateo	0	No Policy
Santa Barbara	0	No Policy
Santa Clara	0	No Policy
Santa Cruz	Unknown	No Policy
Shasta	0	No Policy
Siskiyou	10	Will Test[1]
Solano	0	No Policy
Sutter	0	Will Not Use
Tehama	Unknown	No Policy
Trinity	2-5	Will Not Use
Tuolumne	0	Will Not Use
Ventura	0	Will Not Use
Yolo	Unknown	No Policy
Total	**51-56**	

[1] Will test in accordance with ARB Test Method 435.

Appendix I

Estimation of Costs to State and Local Agencies, and Air Pollution Control and Air Quality Management Districts from the 1990 Control Measure for Asbestos-Containing Serpentine Rock in Surfacing Applications

COST ESTIMATES FOR STATE AND LOCAL GOVERNMENT

For Asbestos-Containing Serpentine Regulation

1. Cost Estimates for State Agencies

The state agencies affected by this regulation are those agencies which build or maintain roads that are fully or partially surfaced with serpentine aggregate (i.e., gravel roads with serpentine aggregate). The staff of the Air Resources Board (ARB) has conducted a telephone survey to determine which agencies build or maintain roads. Based on this survey, the ARB believes that the following three state agencies may incur costs as a result of this regulation: California Department of Transportation, California Department of Forestry, and California Department of Parks and Recreation. Costs for these agencies are discussed below.

With the exception of these three state agencies, we believe other state agencies would incur no costs or negligible costs as a result of this regulation, because no other state agency builds or maintains any significant number of roads surfaced with serpentine aggregate.

a. California Department of Transportation (CalTrans)

CalTrans has the responsibility to maintain an extensive network of roads throughout the state. While the vast majority of these roads are paved roads, some paved roads have shoulders surfaced with aggregate, and CalTrans also maintains a few gravel roads. CalTrans representatives have worked closely with the ARB in developing this regulation and have supplied the ARB with a written estimate of the costs they believe that they will incur as a result of of this regulation. This cost estimate is included with this package as Attachment A.

Caltrans believes that some of the aggregate they use to surface roads and road shoulders may contain serpentine. Some of this aggregate is directly produced by CalTrans from local sources located near various roads, and other aggregate is purchased by CalTrans from outside sources. For material produced by CalTrans from local sources, CalTrans believes that within the first year after the regulations are adopted they will spend approximately $25,000 to survey and test their sources of surfacing material to determine if they contain unacceptable levels of asbestos. CalTrans staff believes that approximately one to 10 percent of their current sites may contain more than 10 percent serpentine and that it would be more cost effective to buy aggregate material from commercial sources than to test these sites for asbestos. They have estimated that they would have additional costs of up to $178,000 per year to purchase this additional material. Hence, in the first year, CalTrans could spend an additional $203,000 as a result of this regulation. Annually thereafter, CalTrans costs are estimated to be $178,000.

b. California Department of Forestry (CDF)

CDF staff believe that they will incur no testing costs as a result of this regulation because they do not produce their own aggregate from local sources. However, CDF staff has estimated that 60% of their $50,000 budget that is allotted for unpaved roads might be indirectly affected by the regulation because they may choose to purchase more expensive alternate material instead of the serpentine that they currently buy. We estimate that CDF could incur an increased cost of $20,000 per year (see Attachment B).

c. California Department of Parks and Recreation (DPR)

DPR staff believe that they may have a few limited sources of local aggregate and may incur a maximum of $1,000 in testing costs. They also believe that any other costs as a result of this regulation will be minimal as compared to their annual budget of $1.5 million for roads (paved and unpaved). They stated that only service roads and fire roads are likely to be unpaved and that there should not be a significant number of these roads surfaced with serpentine material.

2. Cost Estimates for Local Air Pollution Control Districts and Air Quality Management Districts

The ARB usually estimates costs for local air pollution control and air quality management districts (districts) based on the size of the district; larger urban districts generally have higher costs than smaller rural districts. For this regulation, however, we did not estimate the costs based on district size because the districts most affected by this regulation will be those which have substantial serpentine rock deposits and facilities which produce serpentine rock. Many of these districts are small rural districts. We expect the total costs to districts known to have serpentine rock to be higher because they are more likely to have facilities that produce serpentine rock. However, some of the cost components used to calculate total district costs may be higher for the districts known to have little or no serpentine. This is because some of the larger districts surveyed, even though they are known to have little or no serpentine, have higher labor rates and more facilities for which they must determine if the facilities have serpentine. All the tables, formulas and assumptions we used are in Attachment C.

Cost estimates have been based on a telephone survey of 15 districts. Ten of the fifteen districts surveyed are districts that have known serpentine deposits and five of the fifteen have little or no serpentine deposits. The remaining 26 districts may or may not have serpentine deposits. Therefore total costs to these 26 districts were calculated based on the midpoint of the average cost for the 10 districts surveyed known to have serpentine and the average cost for the 5 districts surveyed known to have little or no serpentine. The costs to the local air pollution control districts and air quality management districts have been estimated for three categories: 1) surveyed districts known to have serpentine, 2) surveyed districts known to have little or no serpentine, and 3) districts not surveyed.

The costs that districts will incur as a result of this regulation include the following: costs to formally adopt the regulation, costs to identify the number of serpentine facilities within each district, and costs to enforce the regulation (including any additional staff time necessary to handle public complaints that may arise as a result of the adoption of the regulation). Each of these costs is discussed below.

Adoption Costs

We assumed that all districts will incur costs associated with the initial adoption of the control measure. Based on the survey, the average cost for adopting this regulation for individual districts is approximately $4,000 to districts known to have serpentine, $5,000 to the districts known to have little or no serpentine, and $4,500 (midpoint of the two averages) to the 26 districts not surveyed.

Costs to Identify Facilities

a. First year cost

In addition to the costs incurred by the districts for adoption of this regulation, we expect districts to incur costs for determining the number of serpentine facilities within their district. We assumed that a district will spend, at most, 64 hours to determine the number of serpentine facilities in their district. The average, first year costs for determining the number of facilities could be $800 for each of the ten districts known to have serpentine, and $1,600 for each of the five districts known to have little or no serpentine. For those districts not surveyed, the average, first year cost for determining the number of serpentine facilities is estimated to be $1,200 (the midpoint of the two averages). We also assumed that all the facilities located in districts known to have serpentine would indeed have serpentine. For districts known to have little or no serpentine, we assumed that 10% of the facilities have serpentine.

b. Annual cost

We assumed that there would be no annual costs to the districts for identification of serpentine facilities. We made this assumption because the determination of serpentine facilities conducted in the first year, should not change substantially without the district's knowledge of new serpentine facilities or facilities closing.

Enforcement Costs

a. First year cost

In addition to adoption and identification cost incurred by the district, we expect districts to incur costs for enforcement of this regulation. The enforcement costs include inspection costs and costs for addressing any additional complaints.

For inspections, we assumed that a district would inspect a serpentine facility once a year and audit the facility's receipts of record quarterly. Inspection costs would include district staff time spent at the facility (including travel time), sampling and testing costs (estimated to be $230 per serpentine facility), and costs for quarterly audits. The average inspection cost for the first year to a district known to have serpentine is $7,000. For a district known to have little or no serpentine, the average, first year inspection cost is $5,000. The average, first year inspection cost for the 26 districts not surveyed is estimated to be $6,000 (the midpoint of the two averages).

We assumed that the districts will work on average approximately 4 hours per additional complaint as a result of this regulation. For a district known to have little or no serpentine, we assumed that there would be no additional complaints. (The five districts surveyed under this category believe that they would have no additional complaints as a result of this regulation.) Therefore, there would be no costs for complaints to districts that have no serpentine deposits. The average number of additional complaints in the first year for a district known to have serpentine are estimated at 45. The average number of additional complaints per year for the 26 districts not surveyed are assumed to be 20. The average individual district cost to a district known to have serpentine, for addressing any additional complaints in the first year, is $6,000. The average individual district cost to the districts not surveyed, for addressing additional complaints in the first year, is estimated to be $3,000 (the midpoint of the two averages).

By adding the average costs for enforcement and additional complaints, the average first year enforcement cost to the districts known to have serpentine is $13,000. The average first year enforcement cost to the districts known to have little or no serpentine is $5,000. The average first year enforcement cost to the districts not surveyed is estimated to be $9,000 (the midpoint of the two averages).

b. Annual cost

The average annual inspection cost to the districts are assumed to remain the same as in the first year. The additional complaints, however, should decrease. We assumed that a district known to have serpentine would have, on average, about 20 complaints annually. The districts not surveyed would have about 10 annually. The average annual cost for additional complaints to districts known to have serpentine is $3,000. To the districts not surveyed, the average annual cost is estimated to be $1,500 (the midpoint of the two averages). Districts known to have little or no serpentine are assumed to have no costs for additional complaints.

Again, by adding the average first year enforcement cost to the annual costs for addressing additional complaints, the average annual enforcement cost to the districts known to have serpentine is $10,000. The average annual enforcement cost to the districts known to have little or no serpentine is $5,000. The average annual enforcement cost to the districts not surveyed is estimated to be $7,500 (the midpoint of the two averages).

Individual District Cost

a. First year cost

We assumed that the district's first year cost would include costs for adoption of the regulation, determining the number of serpentine facilities, and enforcement. For a district known to have serpentine, the average, first year individual district cost is $18,000. For a district known to have little or no serpentine, the average, first year individual district cost is $11,000. For the 26 districts not surveyed, the average, first year individual district cost is estimated to be $14,500 (the midpoint of the two averages).

b. Annual cost

We assumed that the district cost annually thereafter would include enforcement only. For districts known to have serpentine, the average individual district cost is $10,000 annually thereafter. For districts known to have little or no serpentine, the average, individual district cost is $5,000 annually thereafter. For the 26 districts not surveyed, the average, individual district cost is estimated to be $7,500 (the midpoint of the two averages).

Total Statewide Costs for all Districts

In order to calculate statewide district costs, we have taken the total cost to the districts surveyed that are known to have serpentine and added this amount to the total cost calculated for the districts surveyed known to have little or no serpentine. We also added the total estimated cost for the 26 districts not surveyed. To calculate this cost, we took the midpoint of the two group averages and multiplied it by 26. The first year statewide district cost is $600,000. Annually thereafter, the statewide district cost is $300,000.

(Attachment C contains the information on which we based our cost to the local air pollution control and air quality management districts.)

ATTACHMENT A:

Memo by California Department of Transportation Explaining the Costs Expected to be Incurred as a Result of this Regulation

State of California | Business, Transportation and Housing Agency

Memorandum

To: R. O. Lightcap, Chief
Division of Project Development

Attention Gary Winters, Chief
Office of Hazardous Waste Management

Date: January 12, 1990

File No.:

From: **DEPARTMENT OF TRANSPORTATION**
DIVISION OF HIGHWAY MAINTENANCE

Subject: Asbestos-Containing Serpentine

I have been requested by Jose Gomez of the Air Resources Board to provide an estimate of cost to Caltrans maintenance should the proposed Asbestos Airborne Toxic Control Measure (as described in draft dated 1/8/90) be implemented.

It is estimated that it would cost Caltrans maintenance forces $25,000 initially, and at least $178,000 per year to comply. Attached to this memorandum are details upon which this estimate is based. This matter has been discussed with Marvin McCauley and Paul Benson of TransLab.

D.E. Delvey

D. E. Delvey, Chief
District Liaison Branch C

Attachment

cc: MLMcCauley - TransLab w/Attachment
PEBenson - TransLab w/Attachment
JGomez - Air Resources Board w/Attachment

DED:vs

Attachment

Following is a discussion of the estimated cost to Caltrans maintenance forces should the proposed Asbestos Airborne Toxic Control Measure -- Asbestos-Containing Serpentine (as described in draft dated 1/8/90) be implemented.

Caltrans has about 15,900 shoulder-miles of unsurfaced shoulders statewide. During the past fiscal year (88/89) maintenance forces performed work on 43,700 shoulder-miles (indicating, on average, shoulders were worked on almost three times per year). This work cost $12,112,000, of which 14.7% was for materials.

Most of the time (perhaps 2/3) maintenance works on unsurfaced shoulders, no material is added; the motor-grader reshapes the existing material to smooth out ruts and rivulets, and to restore the backing material even with the edge of pavement where it has been eroded away by traffic and rainfall runoff. In those cases where material is hauled in to repair the unsurfaced shoulders, it is obtained about half the time from non-commercial sources at little or no cost. These sources would include cut widening at selected nearby sites within the right of way, Caltrans owned or leased material sites, borrow agreements with private owners, permits with other public agencies (counties, BLM, Forestry, etc.). The remaining hauled-in material is obtained from commercial sources. The material cost, 14.7% of $121,112,000 = $1,780,000, would be primarily for hauled-in material obtained from commercial sources.

The primary effect of the Asbestos Airborne Toxic Control Measure would be on hauled-in material from non-commercial sources. Based on the writer's experience in District 11, it is estimated that Maintenance utilizes several hundred (say 400) of these sites statewide. The measure would require that a registered geologist review all such sites to determine if any site contains at least ten percent serpentine material. It is felt that approximately four sites per day could be reviewed by the geologist, allowing time for travel, site inspection and reporting. At $250 per day this would cost $25,000.

If at least 10% serpentine was determined to be present, testing costs could be incurred to determine the percent asbestos or, as appears likely, it would be cheaper to go to a new source free of serpentine. It is estimated that between 1% and 10% of our present sites would contain at least 10% serpentine. Thus, it is believed that up to 40 new sources of material would need to be obtained.

Because the use of aggregate base for maintenance is not great, perhaps only a hundred cubic yards per mile per year, it would often be cheaper to buy the material from a commercial source than to extensively test for asbestos <u>or</u> to acquire, develop and use new serpentine - free sites. (In some remote areas, there will be no commercial sites reasonably available - but this is likely to be rare.)

If we assume we would discontinue use of 10% of our present non-commercial sites, and, instead, purchase commercial material it is foreseeable that our material costs would increase by 10% or $178,000 per year, based on the estimate that half our present material is purchased from commercial sources.

There are many other unknowns involved, such as whether commercial prices would increase significantly if the measure is adopted. However, it is felt that it would be very uncertain to base any estimates on these other factors.

ATTACHMENT B:

Cost Calculations for the California Department of Forestry

Procedure Used to Estimate Cost Increase to the California Department of Forestry (CDF)

CDF staff believe that about $30,000 out of their $50,000 annual budget for unpaved roads could be affected by the proposed regulation. We made the following conservative assumptions in estimating the potential cost to CDF.

-All of the $30,000 is used to buy serpentine material

-The material is purchased at a local source at $5/ton (transportation cost is minimal ~ 50 cents per ton)

-The department buys river rock as the alternative material at $6/ton (not available locally)

-Transportation cost is assumed to add about $3/ton to the price of river rock

Material purchased per year
(assumed to be serpentine) = ($ spent/year)/(price/ton)

= ($30,000/year)/($5.50/ton)

= 5,450 tons/year

Additional cost to purchase alternative material (river rock):

Additional cost = (# of tons/year) * (price of river rock - price of serpentine)

= (5,450 tons/year) * ($9 - $5.50)

= $19,075/year

~ $20,000/year

The percent increase in the Department's budget to maintain current level of operations:

Percent increase = ($19,075/$50,000)*(100)
= 38 percent
~ 40 percent

It should be noted that this is a conservative estimate because we've assumed that all of the $30,000 dollars is used to buy serpentine material that would no longer be available. Also, we assumed that they currently buy all their material from local sources which minimize their baseline transportation costs. We believe that the actual cost increase should not exceed the cost estimated above.

ATTACHMENT C:

Tables, Formulas, and Assumptions used in Calculating Costs to the Local Air Pollution Control and Air Quality Management Districts

Table 1

DISTRICT COSTS*
(estimated)

Categories	# of Districts	First Year Avg. Cost	Annual Avg. Cost
Non-serpentine areas	5	$11,000	$ 5,000
Serpentine areas	10	$18,000	$10,000
Not surveyed **	26	$14,500	$ 7,500

* District costs have been based on a telephone survey of 15 districts that we conducted in January 1990.

** For the 26 districts not surveyed, we assumed the midpoint of the average costs from the non-serpentine areas and the serpentine areas surveyed.

Table 2

DISTRICT PERSON YEARS (PYS) REQUIRED
(estimated)

Categories	# of Districts	First Year	Annual
Non-serpentine areas	5	.13	.05
Serpentine areas	10	.25	.12
Not surveyed *	26	.19	.09

* For the 26 districts not surveyed, we assumed the midpoint of the average costs from the non-serpentine areas and the serpentine areas surveyed.

Table 3

COST TO DISTRICTS (Non-Serpentine Areas)
(Worksheet)

Dist. #	# of Fac. * (w/serp)	Ins. Time (hrs/yr/f)	Qrtly Aud (hrs/yr/f)	Labor Rate ($/hr)	Testing ($)	Inspect Cost ($)	Complts ($)	Enforce 1st Yr ($)	ID Cost ($)	Adoption ($)	1st Year Total Cost ($)
1	27(3)	8	64	40	690	9,330	0	9,330	2,560	0	11,890
9	8(1)	5	28	30	230	1,220	0	1,220	840	4,000	6,060
10	1(0)	6	16	30	0	0	0	0	480	4,000	4,480
14	41(4)	10	64	50	920	15,720	0	15,720	3,200	10,000	28,920
15	1(0)	6	28	30	0	0	0	0	840	5,000	5,840
Avg.		7	40	36	368	5,254	0	5,254	1,584	4,600	11,438

	Annual Inspection ($)	Annual Complaints ($)	Annual Enforcement Cost ($)	Person Years	
				First Year	Annually Thereafter
	9,330	0	9,330	.13	.10
	1,220	0	1,220	.09	.02
	0	0	0	.07	.00
	15,720	0	15,720	.27	.14
	0	0	0	.09	.00
Avg.	5,254	0	5,254	.13	.05

* The number of facilities was taken from the 1989 Division of Mines and Geology data base.

Table 4

COST TO DISTRICTS (Serpentine Areas)
(Worksheet)

Dist. #	# of Fac. * (w/serp)	Ins. Time (hrs/yr/f)	Qrtly Aud (hrs/yr/f)	Labor Rate ($/hr)	Testing ($)	Inspect Cost ($)	Complts ($)	Enforce 1st Yr ($)	ID Cost ($)	Adoption ($)	1st Year Total Cost ($)
2	5(5)	8	16	35	1,150	5,350	6,300	11,650	560	1,000	13,210
3	5(5)	4	8	30	1,150	2,950	5,400	8,350	240	5,000	13,590
4	31(31)	6	8	30	7,130	20,150	5,400	25,550	240	15,000	40,790
5	3(3)	6	16	40	690	3,330	7,200	10,530	640	5,000	16,170
6	7(7)	4	32	40	1,610	11,690	7,200	18,190	1,280	500	20,670
7	3(3)	4	64	25	690	5,790	4,500	10,290	1,600	3,000	14,890
8	3(3)	8	36	20	690	3,330	3,600	6,930	720	5,000	12,650
11	3(3)	6	24	20	690	2,490	3,600	6,090	480	5,000	11,570
12	11(11)	6	16	40	2,530	12,210	7,200	19,410	640	3,000	23,050
13	1(1)	8	32	55	230	2,430	9,900	12,330	1,760	200	14,290
Avg.		6	25.2	33.5	1,656	6,972	6,030	13,002	816	4,270	18,088

	Annual Inspection ($)	Annual Complaints ($)	Annual Enforcement Cost ($)	Person Years First Year	Person Years Annually Thereafter
	5,350	2,800	8,150	.17	.10
	2,950	2,400	5,350	.20	.07
	20,150	2,400	22,550	.54	.25
	3,330	3,200	6,530	.19	.07
	11,690	3,200	14,890	.23	.16
	5,790	2,000	7,790	.27	.14
	3,330	1,600	4,930	.29	.10
	2,490	1,600	4,090	.26	.08
	12,210	3,200	15,410	.25	.15
	2,430	4,400	6,830	.12	.06
Avg.	6,972	2,680	9,652	.25	.12

* The number of facilities was taken from the 1989 Divisions of Mines and Geology data base.

FORMULAS FOR FIRST YEAR COSTS

1. Audit & Inspection Time = Quarterly Audit Time (hrs./yr./serp.fac.) + Inspection Time (hrs./yr./serp.fac.)

2. Sampling and Testing Cost = $230 x # of Serp. Facilities

3. Inspection Cost = $\left[\text{\# of Serp. Facilities} \times \text{Labor Rate} \times \text{Audit \& Inspection Time} \right] + \text{Sampling and Testing Cost}$

4. 1st Year Complaint Cost = (Labor Rate) x (4 hrs./complaint) x (# of 1st year complaints)

   # of complaints (1st year) for districts with serpentine = 45
   # of complaints (1st year) for districts without serp. = 0
   # of complaints (1st year) for districts not surveyed = 20

5. 1st Year Enforcement Cost = Inspection Cost + 1st Year Complaint Cost

6. Identification Cost = Labor Rate x Quarterly Audit Time (hrs./yr/serp.fac.)

7. Adoption Cost = Based on estimated amounts given by the 15 districts surveyed

8. 1st Yr. Total Cost = 1st Year Enforcement + Identification Cost + Adoption Cost

9. 1st Year Statewide Cost = Total 1st Year Cost to Dist. w/Serp. (10) + Total 1st Year Cost to Dist. w/o Serp. (5) + Total 1st Year Cost to Dist. Not Surveyed (26)

10. Total 1st Yr. Cost to Dists. = $\left[\frac{\text{Avg. 1st Yr. Cost to Dist. w/Serp.} + \text{Avg. 1st Yr. Cost to Dist. w/o Serp.}}{2} \right] \times \text{\# of Dist. Not Surveyed}$

FORMULAS FOR ANNUAL COSTS

1. Audit & Inspection Time = Quarterly Audit Time (hrs./yr./serp.fac.) + Inspection Time (hrs./yr./serp.fac.)

2. Sampling and Testing Cost = $230 x # of Serp. Facilities

3. $$\text{Inspection Cost} = \left[\text{\# of Serp. Facilities} \times \text{Labor Rate} \times \text{Audit \& Inspection Time}\right] + \text{Sampling and Testing Cost}$$

4. Annual Complaint Cost = (Labor Rate) x (4 hrs./complaint) x (# of Annual complaints)

   # of annual complaints for districts with serpentine = 20
   # of annual complaints for districts without serp. = 0
   # of annual complaints for districts not surveyed = 10

5. Annual Enforcement Cost = Inspection Cost + Annual Complaint Cost

6. Annual Total Cost = Annual Enforcement Cost

7. Annual Statewide Cost = Total Annual Cost to Dist. w/Serp. (10) + Total Annual Cost to Dist. w/o Serp. (5) + Total Annual Cost to Dist. Not Surveyed (26)

8. $$\text{Total Annual Cost to Dists.} = \left[\frac{\text{Avg. Annual Cost to Dist. w/Serp.} + \text{Avg. Annual Cost to Dist. w/o Serp.}}{2}\right] \times \text{\# of Dist. Not Surveyed}$$

FORMULAS FOR FIRST YEAR PERSON YEARS

Audit & Inspection Time = Quarterly Audit Time (hrs./yr./serp.fac.) + Inspection Time (hrs./yr./serp.fac.)

First Year Complaint Time = # of 1st Year Complaints x 4 Hours/Complaint

# of 1st year complaints for districts with serpentine = 45
# of 1st year complaints for districts without serpentine = 0
# of 1st year complaints for districts not surveyed = 20

Identification Time = Quarterly Audit Time (hrs./yr./serp.fac.)

$$\text{Adoption Time} = \frac{\text{Adoption Cost}}{\text{Labor Rate}}$$

$$\text{First Year Person Years} = \frac{\left[\begin{array}{l}\text{\# of Serp.}\\ \text{Facilities}\end{array} \times \begin{array}{l}\text{Audit \&}\\ \text{Inspect.}\\ \text{Time}\end{array}\right] + \begin{array}{l}\text{1st Year}\\ \text{Complaint}\\ \text{Time}\end{array} + \begin{array}{l}\text{Identification}\\ \text{Time}\end{array} + \begin{array}{l}\text{Adoption}\\ \text{Time}\end{array}}{\text{2080 hrs/yr}}$$

FORMULAS FOR ANNUAL PERSON YEARS

$$\text{Audit \& Inspection Time} = \underset{\text{(hrs./yr./serp.fac.)}}{\text{Quarterly Audit Time}} + \underset{\text{(hrs./yr./serp.fac.)}}{\text{Inspection Time}}$$

$$\text{Annual Complaint Time} = \text{\# of Annual Complaints} \times \text{4 Hours/Complaint}$$

# of annual complaints for districts with serpentine = 20
# of annual complaints for districts without serpentine = 0
# of annual complaints for districts not surveyed = 10

$$\text{Annual Person Years} = \frac{\left[\text{\# of Serp. Facilities} \times \text{Audit \& Inspection Time}\right] + \text{Annual Complaint Time}}{\text{2080 hrs/yr}}$$